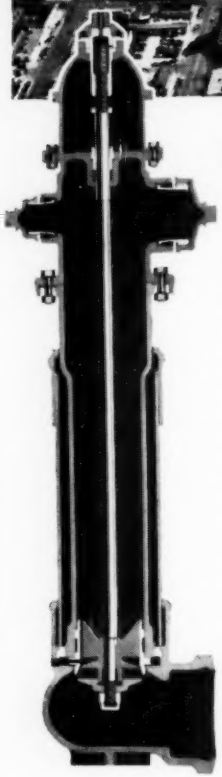
OCTOBER 1949

Journal

VOL. 41 • NO. 10

AMERICAN WATER WORKS ASSOCIATION

Floodwater Detention Structure for Runoff Control



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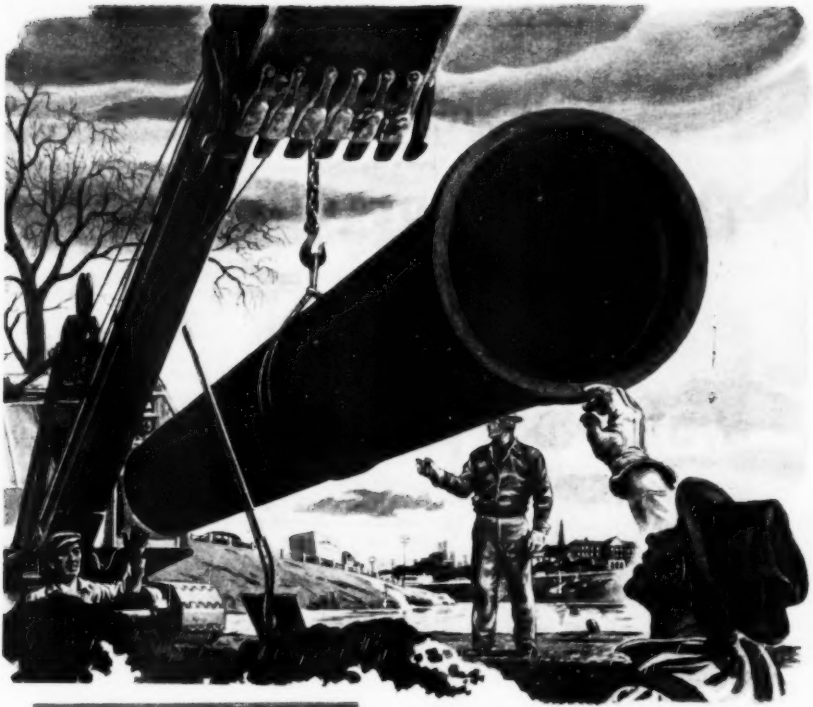

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3. Soil corrosion: Two factors give Transite Pressure Pipe exceptional resistance to corrosion: (1) the materials of which it is made; (2) the especially developed Johns-Manville process of manufacture which imparts a high degree of chemical stability to the finished pipe. This high resistance to corrosion has been substantiated by numerous installations. Many of these are serving as replacements in soils so destructive that the useful life of the pipe materials previously used has been seriously curtailed.

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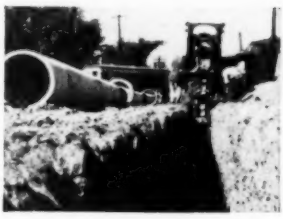

7. Maintenance: In thousands of communities, Transite Pipe—with its advantages of joints that remain tight and flexible, its corrosion resistance, and immunity to tuberculation—provides low-cost water transportation that requires little, if any, maintenance. Transite lines do not have to be cleaned, lined, or replaced because tuberculation has reduced their original capacity. Reports from communities all over the country prove that Transite's asbestos-cement structure provides economies that continue through the years.

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24–25—Virginia Section at Roanoke Hotel, Roanoke, Va. Secretary: W. H. Shewbridge, Asst. Engr., State Health Dept., 713 State Office Bldg., Richmond 19, Va.

26–28—California Section in Sacramento, Calif. Secretary: H. C. Medbery, Chief Water Purif. Engr., Water Dept., 425 Mason St., San Francisco 2, Calif. Hotel reservations through Roy Clair, Mgr., Sacramento Convention Bureau, Chamber of Commerce Bldg., Sacramento 14, Calif.

31–Nov. 2—Kentucky-Tennessee Section at Lafayette and Phoenix Hotels, Lexington, Ky. Secretary: R. P. Farrell, Director, Div. of San. Eng., State Dept. of Public Health, 420—6th Ave., N., Nashville 3, Tenn.

November **2–4**—Chesapeake Section at Wardman Park Hotel, Washington, D.C. Secretary: Carl J. Lauter, 5902 Dalecarlia Pl., N.W., Washington 16, D.C.

3–4—Ohio Section at Dayton Biltmore Hotel, Dayton, Ohio. Secretary: F. P. Fischer, Sales Engr., Wallace & Tiernan Co., Inc., 812 Perry Payne Bldg., Cleveland 13, Ohio.

7–9—North Carolina Section at Highland Pines Inn, Southern Pines, N.C. Secretary: E. C. Hubbard, Prin. San. Engr., State Board of Health, Raleigh, N.C.

11–13—Arizona Section at San Carlos Hotel, Yuma, Ariz. Secretary: Mrs. Helen Rotthaus, San Eng. Div., State Dept. of Health, Phoenix, Ariz.

14–16—Florida Section at Orange Court Hotel, Orlando, Fla. Secretary: A. E. Williamson Jr., P.O. Box 1431, Daytona Beach, Fla.

17–19—New Jersey Section at Madison Hotel, Atlantic City, N.J. Secretary: C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

December **5–7**—Southeastern Section at Gordon Hotel, Albany, Ga. Secretary: T. A. Kolb, San. Engr., State Board of Health, Wade Hampton Bldg., Columbia, S.C.

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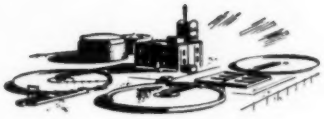

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Journal

AMERICAN WATER WORKS ASSOCIATION | **October 1949**

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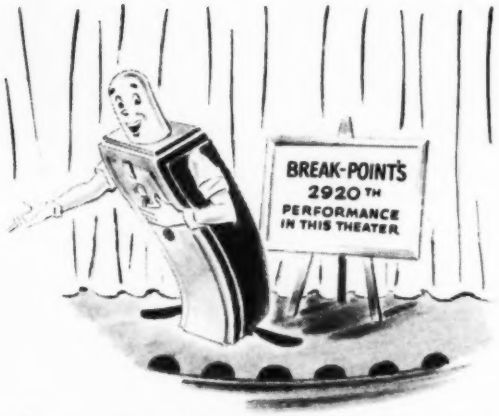
8 YEARS AND STILL GOING STRONG



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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 41 • OCTOBER 1949 • NO. 10

Sanitary Service Charges in Tennessee, 1948-49

Tennessee State Planning Commission Report

A condensation of a report presented by the Tennessee State Planning Commission, under the direction of Charles L. Crangle, Acting Director, Div. of State Planning, Nashville, Tenn.

COMMUNITIES of today perform a large number of services for their citizens; perhaps none are more important than those in the field of sanitation. Without a satisfactory water supply, few towns and cities could long exist. Without sewerage systems and garbage and trash collection and disposal, communities would rapidly become pestholes of disease from which citizens would flee.

The provision of water is one of the earliest of public service enterprises. Sewerage and garbage collection services are much newer functions of the city government, the demand for them generally having arisen during the last century as communities grew and private disposal of wastes was no longer either safe or satisfactory. These services were added to municipal budgets at a period when most cities were in a more favorable financial state than at present, and the cost was accordingly met initially from the general fund, raised by means of a tax on the real and personal property within the municipality.

Since the early 1920's, however, communities have faced increasing difficulties in attempting to make the general property tax cover an ever larger number of services. This has been particularly true in Tennessee because the general property tax system of most of its communities is badly in need of reorganization. The second world war and its aftermath witnessed increases in the cost of both materials and labor, which served to accentuate the problem. The schools of America today are more extensive and costlier plants than in grandfather's day; paved streets and sidewalks are now the rule rather than the exception; community recreation, including indoor facilities as well as parks and playgrounds, is being increasingly demanded; and police and fire protection on a professional basis are now gener-

ally accepted community responsibilities.

All of these facilities cost money. Providing them has made municipal government a big business—often a bigger business than any single industry in the community. Unfortunately, particularly in Tennessee, funds for such services have not kept pace with demands. Aside from the general property tax, cities and towns have little power to levy and collect taxes. The field of luxury taxes, including taxes on cigarettes and tobacco and beer and other alcoholic beverages, has been preempted by the federal and state governments, although Tennessee does share with incorporated communities the revenues from the beer tax, sales tax and the income tax on stocks and bonds.

The general property tax has been slowly declining as a source of municipal revenue, not altogether owing to inadequate assessment. Ever since the mass production of the automobile, home owners have been tending to move beyond the city limits, to enjoy a more rural existence and to escape the city property taxes. These conditions have placed many communities in a serious dilemma. At a time when they are being called upon to provide an increased number of services, their chief source of revenue is failing them.

As a result, communities today as never before must plan to put their services on a self-supporting basis whenever this can be done. It is no longer possible to make a small charge for water service and meet any deficit or expenditure for new extensions out of the general fund. And few communities in Tennessee can afford to provide sewerage and garbage collection from property tax levies when the product must be disposed of in such a manner as to safeguard the health of the people.

Sanitary services are items to which the ordinary citizen living in a community necessarily subscribes on the same basis as for electric current, yet no one has suggested that the community provide free electricity and finance it from the general property tax. It is realized that one citizen, for any number of reasons, may use three or four times the amount of electricity that his neighbor uses. Water bills have generally included a minimum charge which covers the use of the system and provides a certain specified amount of water for each customer. A similar charge may easily be set up for sewerage and garbage collection services. Placing them on a self-sustaining basis will leave the general tax funds for other community endeavors whose cost is not so simply apportioned.

Although most municipal authorities are today in accord on the advisability of making a charge which would enable these three services to be self-supporting, there is difficulty and lack of agreement on three major questions: [1] What is a valid water rate? [2] How can sewer charges be apportioned? [3] What charge should be made for garbage collection service?

[This publication, stemming from a survey of the majority of Tennessee communities, discusses the above questions as they apply specifically to the cities and towns of that state. The present condensation, however, is limited to water rates.—*Ed.*]

Rate Basis

The term "water rate" is used to designate the schedule of charges made for water service. The water rate is, then, a convenient means for billing the cost of collecting, preparing and delivering water to customers.

There are three general ways in which a water charge is developed.

The use of a water meter is, of course, the most equitable manner of arriving at a basis for the charge; the meter measures the amount of water used by the particular customer and a charge is made on the basis of this consumption. The cost of water meters is sizable, however, and a number of smaller communities find this initial investment in equipment a serious difficulty. Yet such an investment, if handled with intelligence and experience, is one that almost invariably pays two kinds of dividends. It secures revenues based on the quantity of water used, increasing the aggregate gross income. At the same time meters husband and conserve the water supply and promote prompt attention to leaks. They penalize and so discourage waste, thus making the reservoir facilities sufficient for servicing a larger population. They provide the essential readiness to serve that is of such importance and value in securing new industries and in retaining existing labor-employing and taxpaying institutions.

A second basis for rendering water bills, known as the "flat rate," is often utilized, particularly in small towns. This charge is based on the number of fixtures installed, the number of rooms in the home, the number of occupants or other considerations. Obviously, a rate of this nature bears little relation to the amount consumed or to the cost of the service. However, for unmetered water supplies, the flat rate is usually the popular choice, particularly if the water supply is free flowing or practically unlimited. If the rate is properly set, such a flat charge will probably be satisfactory in communities which possess little in the way of commercial or industrial establishments.

The two methods of fixing the water charge discussed above are the usual choices in Tennessee. A third method, which has found some favor in other states, bases the rate on the valuation of the property served or on its rental value. Property value is, of course, hardly more indicative of the water consumption or water needs than is the flat rate previously discussed. It does, however, have the advantage of being a simple method and one that is easily kept up to date. It has sometimes been favored because it charges for water service on the basis of ability to pay. If the water system is being run in a businesslike manner, this criterion is hardly legitimate, and if the owner pays the bill, the charge might more simply be added to the property tax.

Revision of Rates

Whatever form the water rate eventually assumes, it should produce sufficient revenue to operate the system, to meet the interest and amortization costs of the bonds issued to pay for the system, and to put aside a certain amount every year into a reserve fund which will finance needed extensions to the system, repairs and replacements, and possibly provide a nest egg to aid in the construction or reconstruction of major items at a later date when the present system becomes outmoded.

Unfortunately, a number of the water rates currently in effect in Tennessee do not satisfy the above requirements, which are those of any good business enterprise. Many schedules bear evidence of having been hurriedly established by the simple device of borrowing rates already in effect in nearby towns and cities. Such rates show no signs of having been the result of careful consideration of the operating cost of the system in question and often bear little relationship to the interest rate and amortization of the bonds outstanding against the system. This condition is more likely

to be present in the older systems than in those more recently constructed, for, where the newer device of issuing revenue bonds to pay for the system has been utilized, bond houses insist on rates that will pay the cost of operation, maintenance and debt service. Where the full faith and credit of the community has been pledged by way of general obligation bonds, however, too little care has sometimes been taken to insure a revenue sufficient to meet bond requirements.

In this situation, customer reaction to the rate seems to have been the final test of its desirability. If no complaints against the rate are received, it is considered to be satisfactory. A rate set up in this manner is subject to abuse. Since the community is likely to be short of money, there is always the temptation to raise the rates if no one protests. And, conversely, when no real study of the cost of providing the water forms the basis of the rates, there is often strong pressure to lower the charge. Municipal officials who possess no figures on the actual cost of the water service find it difficult to fight such a tendency.

A good water rate should have as its basis an up-to-date listing and appraisal of all the property, operating capital and operating costs of the system. Such an inventory should be revised at stipulated times so that the records are reasonably accurate whenever the question of increasing or decreasing the rates arises.

It is obvious that a rate which fails to meet the cost of providing the service necessary should be revised in order that it may do so. It is equally apparent that rates changed too frequently result in confusion in the minds of the customers and in a vast amount of bookkeeping changes. Once a rate has been set on the basis of cost of service, bond payments to be met and accumulation of a reserve fund, however, the rate should be satisfactory for a number of years. The best authorities in the field of water system financing agree that the rate schedule should be reviewed with the idea of revision at least once every ten years. Adjustments should be made at that time in order to assure the income needed to run the system properly. Increased cost of supplying water, additional treatment required and loss of customers are some of the considerations which may make an increase in rates necessary at the time of review. On the other hand, as bonds are redeemed and the system paid for, it should be possible, all other considerations remaining the same, to reduce the rate. It has been suggested by a number of authorities that, rather than reducing the rate in a favorable period, it might be more advisable to accumulate a larger reserve fund which would tend to offset increased cost of service during future eras of higher prices. This question the community itself must decide. When there is doubt or lack of agreement, however, expert engineering and accounting advice should be obtained.

Political Interference

In by far the majority of towns and cities in Tennessee, the provision of water service is a municipal responsibility. Of the 218 public water supplies in the state, only 56 are privately owned and only one of these—the City Water Co. of Chattanooga—is of any real size. The majority serve less than 300 people. The remaining 162, with the exception of five which are federally owned and operated, are the property of the community or utility district which they serve and are run for the benefit of the citizens.

Good management should, of course, be a watchword at the municipal water works. Since no water rate will be satisfactory if the system is badly managed, it seems important to discuss here a few of the detriments to good operating efficiency of the local water system.

Politics sometimes results in mismanagement. It is hardly necessary to call attention to the fact that partisan political considerations should never enter into the provision of water service or any other municipal function. The release of experienced, trained water department personnel after a municipal election makes for poor operating efficiency, and poor collection procedures and policy often result. Once rules and regulations for the water system have been adopted, they should be carried out without favor or interference by outside interests. Water charge collections should always be kept current, and it should not be possible for anyone to avoid payment of his bill for service, or to secure preferential treatment.

Diversion of Funds

Another condition detrimental to good operating efficiency, which is often met in Tennessee, is the practice of confiscating all or a portion of the cash balance or apparently surplus earnings of the water system and transferring it to the general fund for other municipal purposes. Municipal officials attempt to justify this action with the argument that the water system shows a profit, the property tax fails to provide the total amount needed for running the city and therefore such transfers are necessary. It is doubtless true that a great many cities and towns would be in serious difficulties if water revenues were not used for other municipal functions, but it is also true that the present haphazard policy of turning to the water funds for additional monies whenever the city government needs funds makes it impossible to operate the utility in a businesslike manner. The water system officials have no idea from year to year how much the city government will take and consequently can do no real planning for the maintenance, improvement and extension of the system, since the necessary backlog of cash which any business needs to see it through difficult times and to care for capital improvements is likely to be lacking just when most required.

The answer to this problem seems to lie in placing payments from the water funds to the city on a regular basis, by which the water system would make periodic tax equivalent payments to the municipality according to the value of its holdings, in precisely the same manner as private business would pay taxes. Water system officials would then be able to include these payments in their anticipated disbursements when making up the annual budget and would be able more nearly to estimate the surplus that could be devoted to the improvement and upkeep of the system.

Although tax equivalent payments are a relatively new idea in Tennessee, most water systems have for years had to make a more or less fixed contribution to municipal government over and beyond the levies on their surplus, in the form of free water to city departments. The amount of such water used in fire fighting and street flushing alone is likely to be large. Good business practice calls for regular billing of all city departments for the amount of water they use if a system of tax equivalent payment is embarked upon. Only a small number of Tennessee communities today have a

hydrant rental fee, and few of these obtain cash receipts from this service. Some enter the item on their books and then charge it off as uncollectible. A hydrant rental fee is the fairest way of offsetting the loss to the water system from water used in fire fighting and street flushing operations and of maintaining the investment involved, and should at least partially make up the discrepancy between the amount of water the system pumps and the amount for which the citizens are billed. A hydrant fee of $25 a year for each installation is generally considered reasonable and will be easily offset by the savings to the community in fire rates because of the water protection afforded.

Industrial Rates

Tennessee is a state that is rapidly becoming industrialized, and, accordingly, in a number of communities, low industrial water rates have been proposed as an incentive to new industry. Understandably, this is an attraction, and it is likewise true that water can be provided in large amounts to an individual consumer much more cheaply than to a number of small ones. However, before any community decides to encourage industry by low water charges, it should be certain that sufficient water to supply the prospective industrial demand, as well as the growth expected in the population for a period of years ahead, is available and that it will not be necessary to build expensive additions to the plant in order to process an amount of water out of keeping with the advantages to be gained. In setting the industrial rate, the cost of supply lines to the plant, the maximum rate of demand and seasonal variations in the demand should be considered. The final rate should be such that the costs of supplying the additional water do not fall on the other users. It should also be remembered that once a special rate has been allowed, a precedent is set, and it will be very difficult to refuse succeeding requests for similar rates.

Suburban Extension Policy

Finally, as suburbs have grown up around the cities, these areas have repeatedly requested city water service and, while resisting incorporation into the city, have felt that the community utilities should be made available to them. It is only sound business practice to hold to the rule that, when a community provides water service to an adjacent area, the area requesting such service must expect to pay higher rates than do the citizens residing within the city limits and paying city taxes. The community is under no compulsion to serve outside residents, and when it does so it should be in the spirit of any business enterprise, with the expectation not only of financing the necessary lines and equipment but also of making a profit from its service.

Not a few water systems have imperiled their solvency and unnecessarily burdened their citizen owners and customers by investing in elaborate distribution extensions to new subdivisions, then belatedly finding that the subdivisions failed to materialize to an extent warranting the investment. Requiring the promoters of the subdivision to finance the construction of the extension desired and to give a corporate surety bond assuring a minimum return on the cost of the supply main is one dependable way to avoid financial loss through boom time developments.

Moreover, if the community charges no more for service outside its corporate limits than within, there is no incentive for outside areas to become

part of the city. The willingness of cities to provide water service to residents and industries located outside their boundaries has probably often been an important factor in influencing construction beyond city limits, to the detriment of city property taxes.

Factors for Consideration

Before revising the water rate, all of the above factors should be carefully considered. It should be remembered that raising the water charge is bound to provoke a good deal of discussion and is likely to face serious opposition as well. The responsible municipal officials should, therefore, be certain that the rate they propose will meet conditions for a number of years to come, making unnecessary a renewal of the discussion within a year or so. In order adequately to reply to questions that will certainly be raised, as well as to insure a valid basis for the new rate, answers to the following should be known well in advance: [1] Have past revenues been adequate? [2] How much money is required yearly to meet operating and maintenance costs and the interest on and amortization of the bonded debt? [3] Are large capital improvements contemplated in the near future? [4] Have funds for future construction been accumulated and, if so, how much? [5] How much deferred maintenance work accumulated during the war? [6] Will the water system make tax equivalent payments to the municipality, and, if so, what will be the yearly amount? [7] What is the probable rate of growth of the community and thus of the system; that is, what extensions of service will probably be necessary within the next few years? [8] What is the probable cost of labor and materials needed for construction in the individual community?

Having explored all these problems, the local officials should be able to establish a rate that is equitable and just to all for the present and for from six to ten years ahead, and therefore one which responsible citizens will support.

Water Rate Data

Of the 218 public water supply systems operating in Tennessee in May 1949, the present survey gives information on 164 facilities, including all but two of those serving populations of over 3,000. The systems not represented are, therefore, comparatively small ones, which, though polled, failed to provide the desired information.

For comparative purposes, the individual charge for 2,500, 5,000 and 10,000 gal was computed. When the minimum allowed was over 2,500 gal., it was, of course, necessary to use the minimum figure. The comparative rates were calculated for domestic use inside the city limits only, and when rates were based on meter size the usual domestic meter size was employed in figuring the charge. Rates given in cubic feet were converted to gallons for purposes of comparison.

The survey brought forth a number of interesting facts concerning the water supply systems of the state. Wells and springs form 76 per cent of the state's municipal water supply sources, while streams and lakes account for only 11 per cent. The remaining 13 per cent of water supplies come from more than one source—springs plus streams, for example—or from other community or private systems. It was further determined that 23 per cent of Tennessee water supplies receive no treatment whatever, while 35 per cent receive only disinfection before being delivered to the consumer.

A majority of the local water systems meter their water: of 164 communities

reporting, only 21, or 13 per cent, lack meters and make a flat-rate charge to their customers. With four exceptions, all these communities have populations of less than 1,000; the remaining four have less than 3,000.

It is generally agreed among water rate experts that the cost of supplying 2,500 gal. of water to a customer in a community of under 1,000 population averages from $3.00 to $3.50 per month; on that basis, no Tennessee community in this population range charges enough for the service rendered. Charges for this amount of water in Tennessee communities of under 1,000 population vary from a low of $1.00 in Tellico Plains to a high of $2.50 in Decherd, Lafayette and White Pine. The average bill for a minimum or 2,500 gal. of metered water is $1.83.

Although water service should become increasingly cheaper as larger populations are served, the entire range of rates in Tennessee is still remarkably low. In the 1,000–3,000 population bracket, in which 46 communities reported metered rates, the lowest charge for 2,500 gal. of water is $1.13, in Dyer, while the highest charge is $2.63, in Hartsville. The average bill for the minimum or 2,500 gal. of metered water in this population bracket is $1.74.

In the 3,000–5,000 class, 22 communities charge an average of $1.45 for 2,500 gal. of water. The lowest charge is $1.13 in Dickson and Mount Pleasant, while the highest is $2.50 for customers of the Daisy–Soddy–Falling Water Utility Dist. of Hamilton County.

The 15 cities of between 5,000 and 10,000 population make an average charge of $1.44 for the minimum or 2,500 gal., bills ranging from a low of $0.88 in Union City to a high of $2.25 in Paris.

In the 10,000–35,000 bracket, eight cities reported rates for the initial 2,500 gal. ranging from $0.75 in Cleveland to $1.25 in Jackson and Kingsport.

The four largest cities of the state reported, as was to be expected, the cheapest rates of all. Nashville furnishes 2,500 gal. of water at $0.60. Chattanooga, a privately owned utility, furnishes its minimum amount of water for $0.75, while Knoxville charges $0.85 and Memphis $1.00. The average bill for these four cities is $0.80.

Reasons for Low Rates

There are several ways to account for the number of low water rates in Tennessee. Perhaps the two most pertinent explanations, aside from failure to consider the cost of the service, are: first, the fact that many of the systems were constructed more than 20 years ago, when costs were much lower than today; and, second, the fact that some were constructed during the depression years with federal aid from the WPA and PWA, the federal government financing as much as 45 per cent of the cost. Often, therefore, the water bill does not represent the need to pay off any sizable bonded indebtedness. Unquestionably, if any of these systems were to be reproduced today, the rates charged would have to be more than double the present ones.

The water rates surveyed indicate a certain amount of indirect subsidization of industries through much lower rates than would otherwise be justified. Of course, water can be supplied to individual large consumers at much lower rates than to smaller users, but a number of the rates seem unnaturally low, even considering this factor.

Another group being served at rates which sometimes probably do not reflect the true cost of the water delivered consists of those residential

customers living outside the city limits who pay no municipal property tax, yet receive and are charged for their water service at the same rates as residents of the city. Sound business practice and fairness to the municipality's citizens presume that higher rates should be charged for service outside corporate boundaries. Only 27 Tennessee communities—seven more than in 1947—reported a higher rate for service outside their corporate limits.

A number of the municipal water rates are unnaturally complex and would benefit from simplification. In one community, the rate changes at 100-cu. ft. intervals. There is evidence, too, that some of the rates need complete revision. For example, in a few systems, an outdated rate is still in effect with amendments stipulating that a certain percentage of the bill be added after computation, or providing that a flat amount be added to each bill, with no regard to the amount of use.

The majority of water rates in effect in Tennessee, however, were found to be of comparatively recent date. Of the 137 water systems reporting the date of rate adoption, the average date for communities of under 1,000 was 1939; for communities of 1,000 to 3,000, 1941; 3,000 to 5,000, 1944; 5,000 to 10,000, 1942; 10,000 to 35,000, 1937; and over 35,000, 1937. The average overall effective date was, thus, 1940. The earliest water rate still in effect in Tennessee is probably Cleveland's, adopted about 20 years ago. Twenty-one cities adopted new water rates in 1947, 22 made new rates effective in 1948 and 11 have adopted new rates in 1949. Thirty-four per cent of the communities reporting are still utilizing rates established prior to 1941 (compared to 56 per cent having pre-1941 rates, according to the 1947 report), but only 13 communities are still employing rates adopted prior to 1929, indicating that since 1947 Tennessee water rates have risen to some degree in accordance with the increased costs of operating and maintaining the local water plants.

The study of bonded indebtedness of the 164 cities of the state reporting their water charges indicates that a far greater number of general-obligation bonds than of revenue bonds is outstanding. Since data were not available on the dates of bond issuance, this information does not necessarily indicate present trends in bonding. Attention should also be called to the fact that a number of the issues listed are multiple purpose, which may have influenced the choice of general-obligation bonds. Seventy-five issues of this type of bond were found to be outstanding in the cities' studied, totaling $16,274,491. Fifty-two revenue bond issues were noted, totaling $6,247,962. The number of revenue bond issues is not only smaller, but the individual amounts outstanding are much less.

Conclusion

Although municipal water rates in Tennessee have been increased notably during the years 1948–49, they still probably fail to reflect the actual cost of water service in many systems. A number of the rates, particularly those of longest standing, will probably require revision in the near future, if the water systems are to render the service required of them and at the same time make necessary extensions and capital improvements in an era of unprecedented high prices. Only a competent and painstaking study of all the factors involved in the individual system can establish the precise degree of need for rate adjustment. Such individual studies should be undertaken by many communities as soon as possible.

Factors Involved in Control of Water Supply Quality

Panel Discussion

A panel discussion presented on June 1, 1949, at the Annual Conference, Chicago.

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IN August 1948 a communication was sent out by the Association's Secretary to state sanitary engineers and other persons, inviting comment on certain possible "adverse factors affecting public water supply safety." Speaking only for Massachusetts, the author stated in reply:

1. *Inadequacy or lack of protection of ground water supplies:* "The problem of protecting ground water supplies in Massachusetts is not serious since they are located in areas remote from sources of pollution, and in the sand and gravels of the state which afford adequate filtration of percolating waters."

2. *Excessive pollution of surface sources of supply:* "There is only one source of water supply in Massachusetts which is taken from a source known to be polluted, viz., the City of Lawrence, which receives the sewage from the larger municipalities in Massachusetts and New Hampshire upstream from the city of Lawrence."

3. *Inadequate treatment works for surface supplies:* "In the opinion of this Division, the surface water supplies in Massachusetts are provided with adequate treatment."

4. *Failure to operate water purification systems properly:* "The water purification systems in Massachusetts are operated satisfactorily, with the exception of one iron removal plant, which, however, does not present a health hazard."

5. *Pollution of water in the public distribution system:* "This Division is seldom faced with the problem of pollution of the water in the public distribution system."

6. *Pollution of water within domestic and industrial plumbing systems through back siphonage:* "This Division has no evidence of the pollution of the water supply within domestic and industrial plumbing systems through back siphonage."

7. *Lack of recognition on the part of public officials for the need of trained personnel to operate water systems;* 8. *Incompetence or lack of training of water works personnel:* "While it is desirable that personnel with a greater degree of formal training and education than is customary be available for the operation of water works systems, there is no doubt . . . that the public officials recognize such a desirability although budgetary considerations have prevented the employment of personnel with formal health education. It is my opinion that salaries customarily offered to water works personnel are not sufficient to attract sanitary engi-

neers to such positions, and it is my further opinion that the sanitary engineering training is a valuable asset to the New England water works superintendent."

In treating this subject, one might well consider: [1] the advances made over a number of years in the protection of the public health through improvements in public water supplies; and [2] the existing hazards, if any, and an evaluation of them.

The present discussion, therefore, should be in the nature of an inventory of the ability of the men engaged in water works practice and in the sanitary engineering profession—including laboratory personnel—to meet these public health responsibilities. After evaluating this ability, an attempt should be made to determine what additional responsibilities must be assumed by these professions to provide any necessary additional protection.

Drinking Water Standards

On October 21, 1914, in accordance with the interstate quarantine regulations and the recommendations of the then surgeon general, the Treasury Dept. adopted the first so-called "standards" for drinking water supplied to the public by common carriers in interstate commerce. At that time the limitations placed on the presence of organisms of the coliform group were to the effect that not more than "one out of five 10-cc. portions of any sample examined should show the presence of organisms of the bacillus coli group." The technique for making this test was similar in most respects to the present standard methods of bacteriological examination.

The drinking water standards established in 1914 were superseded by those adopted by the Treasury Dept. on June 20, 1925; again on September 25, 1942; and again on February 6, 1946.

No detailed specifications were set up in 1914 regarding the chemical properties of the water thus supplied, this question being "left for further discussion." The drinking water standards adopted in June 1925 expanded somewhat the bacteriological requirements of 1914 in that: [1] of all the standard (10-ml.) portions examined in accordance with the procedure specified, not more than 10 per cent were to show the presence of organisms of the *"B. coli"* group; [2] occasionally, however, three or more of the five equal (10-ml.) portions constituting a single standard sample were permitted to show the presence of *"B. coli."* This result was not allowable if it occurred in more than "(a) 5 per cent of the standard samples when 20 or more samples have been examined; (b) one standard sample when less than 20 samples have been examined."

These standards were adopted with the understanding "that in the examination of any water supply the series of samples would conform to both [1] and [2]. For example, where the total number of samples was less than six, the occurrence of positive tests in three or more of the five portions of any single sample, although it would be permitted under requirement [2], would constitute a failure to meet requirement [1]. . . ." Therefore, the 1925 standards were more rigid than those of 1914 from a bacteriological point of view.

Finally, under the 1946 requirements, recommendations were made for the collection of a considerably greater number of samples than in the

earlier standards of 1925 and 1914. Thus the standards of 1946 became more rigid, because of their application on a *monthly* basis, when formerly the application had been on a *yearly* basis, and because of the larger numbers of samples recommended, which increased the chance of finding bacteria of the coliform group, if present. The 1946 standards also contained more rigid requirements on the chemical quality of the water.

The U.S. Public Health Service also has established certain recommendations on water sanitation practices (1). These requirements presumably are needed to maintain a bacteriological condition of the water to meet the standards. With most of the requirements, the author believes, the majority of state sanitary engineers have no quarrel. Certain provisions in this manual, however, might not be considered by every sanitary or water works operator as necessary at all times in order to maintain a water of satisfactory quality. For example, the qualifications establishing the responsibility of a person making a sanitary survey might rightfully be regarded as rather rigid for a simple water supply and as involving an unnecessary amount of paper work. Certain specifications covering filtration plants, distribution systems and chlorination are more rigid than is practicable for some of the smaller supplies.

Comparison of Health Hazards

In view of these additional requirements it might be well to compare the public health hazard existing in 1914 and in 1946 in connection with public water supplies.

TABLE 1

Probability of Contraction of Typhoid Fever From Public Water Supplies in Massachusetts Relative to the Probability in 1925

Year	Population	Population Served by Public Supplies *per cent*	Typhoid Morbidity Rate per 100,000	Observed Avg. Coliform Density No./100 ml.	Permissible* Coliform Density No./100 ml.	Typhoid Probability Based on:	
						Observed Coliform Density	Permissible Coliform Density
1914	3,639,803	65	63.4		2.23		4.3
1925	4,143,724	75	13.7	0.95	1.05	1	1
1946	4,567,621	95	0.65	0.27	1.05	0.070†	0.24

* Drinking Water Standards: permissible coliform density equals $2.3(10) \log \frac{1}{1-p}$, in which p is the proportion of 10-ml. tubes permitted to be positive.

† $0.070 = \frac{(0.65)^{0.461} 0.27}{(13.71)^{0.461} 0.95}$.

In 1914 the Massachusetts case rate for typhoid fever was about 64 per 100,000, while in 1946 it was 0.73 per 100,000. Therefore, so far as the typhoid fever case rate is concerned, it would appear fair to ask whether the state is becoming too *increasingly* rigid in connection with the protection of its water supplies. To assist the Massachusetts Div. of Sanitary Engineering in answering this question intelligently, the services of Harold A. Thomas Jr., Associate Professor of Sanitary Engineering of the Harvard

Graduate School of Engineering, were engaged. Thomas has made a careful mathematical analysis of the probability of the contraction of typhoid fever from public water supplies (Table 1). The following constitutes his conclusion from this analysis:

> The implication of the result shown in the last column in Table [1] is that water supplies in 1925 had about four times the capacity for transmitting typhoid that water supplies with the same coliform density have today. Yet it is manifest that the 1925 standard was a safe standard: in compliance with it the number of typhoid cases traceable to water supplies became vanishingly small. Under present conditions the same degree of safety could be attained by relaxing the standards so as to permit 35 per cent of 10-ml. tubes to be positive.

Gastroenteritis and Typhoid

In recent years the Massachusetts Div. of Sanitary Engineering has been increasingly concerned with so-called gastroenteritis cases called to its attention by health officers who, for want of any other common factor in their epidemiological studies, blame such outbreaks on the public water supply. Some of these cases have occurred at a time when certain aerobacters have appeared in the distribution system, especially during the warmer months of the year. The presence of these organisms has encouraged the carrying of unreasonably high chlorine residuals in the water although there is no concrete evidence that these types are disease-producing and in spite of the fact that some aerobacters are highly resistant to chlorination. To carry such residuals in some supplies would result in sloughing off the slime coating which has proved a safeguard against lead poisoning from the many lead services connected with certain soft surface water supplies. The cost of removing these services would be great and the slime coating in the past has prevented the taking up of lead by the water. Taking into consideration that no lead poisoning now occurs, that chlorination at the source apparently keeps the supplies free of known pathogens and that the chlorine residual usually carried in soft waters is generally not enough to destroy cysts and certain viruses or remove some of these aerobacters satisfactorily, is it justifiable to demand that a water department go to the expense of removing the lead services or increasing chlorination?

At this point it might be well to explore 353 cases supposedly waterborne in Massachusetts public supplies during 1938–45. Actually only 90 of these cases could remotely be correctly attributed to the use of a public water supply. So far as can be determined, the history of all of these cases is as shown in Table 2.

Conclusions

The author firmly believes in the necessity for maintaining a uniform practice of adequate supervision of public water supplies regardless of the fact that infections from waterborne diseases have practically disappeared. He is equally firm, however, in the opinion that the time has arrived for evaluating sanitary engineering practices in connection with public supplies. Before adopting procedures which may prove to be a great financial burden on the water consumers, it must be shown that such practices have a real bearing on the public health.

Recently there was reported an epidemic at Loudonville, Ohio, believed to have been caused by the breakdown of a chlorinating machine. The author does not wish to imply that a single

TABLE 2

Massachusetts Outbreaks Supposedly Waterborne, 1938–45

Municipality	Type and Date of Outbreak		Reported Cause of Outbreak and No. of Cases			
	Gastro-enteritis	Typhoid	Public Water Supply	Semi-Public Water Supply	Cross Connections Between Public Supplies and Questionable Private Supplies	Unsafe Private Supplies, Faulty Plumbing or Other Cause
Deerfield (So. Deerfield Water Supply Dist.)	Apr. 1938		large number			
Middleborough (In factory)	Nov. 1938				68*	
Palmer (Three Rivers)	Jan. 1939			50		
Boston (No pollution of water in street mains)	Apr. 1939					back siphonage 15
Framingham (Private well at roadhouse; no connection to street mains)	Sept. 1939					private well or food 75
Salisbury Beach (No connection to street mains)		Sept. 1939				private well 2
Quincy (No connection to street mains)		July 1939				private spring and brook 4
So. Hadley Fire Dist. No. 2	Apr. 1940				90	
Quincy (No connection to street mains)		July 1940				private wells or springs 5
Fall River (In plant only)	June 1941					back siphonage 2
Boston (No connection to street mains)		Jan. 1941				private spring 2
Salisbury (No connection to street mains)	July 1941					private well 40

* Possibly cross connections, possibly milk.

such apparatus was adequate for the protection of that supply, but he does desire to point out that a duplicate chlorinating installation—or any chlorinating apparatus at all—may be unnecessary for many ground water supplies. Attention should be centered on simplifying rather than complicating water works practice. So far as practicable, the elimination of cross connections and back siphonage conditions should be urged, but the consuming public should not for a moment be given the impression that there is a lack of ability to meet the many problems of safeguarding the water supply. Irresponsible publication of water works discussions by uninformed writers can give that impression. Such publication will be encouraged by the establishment of unreasonable standards and requirements for water works.

Reference

1. Water Sanitation Practices. Bul. 296, U.S. Public Health Service, Washington, D.C. (1946).

Charles R. Cox

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The current interest in potable water quality embraces the consideration of physiological effects of trace elements such as fluorine and iodine, the possible connection between the sodium content of potable water and high blood pressure, the correlation of the nitrate content of water with cyanosis in infants and similar considerations, as well as the bacteriological quality of potable waters. The present discussion is concerned with evaluating the sanitary quality of public water supplies and waterborne diseases.

It is pertinent to inquire the reason for the sudden rebirth of interest in waterborne diseases, in view of their low incidence and the generally satisfactory status of public water supplies, as indicated by others participating in this panel. It seems rather evident that the answer lies in recent popular literature designed to secure public support of water pollution control programs. This literature unfortunately has at times been of an alarmist nature and has resulted in broad conclusions being erroneously reached in the popular press through the oversimplified use of summarized statistics on public water supplies. Constructive conclusions can be reached only by a technical study of basic data surrounding specific outbreaks of waterborne diseases.

Waterborne Disease Statistics

For instance, summarized statistics on waterborne diseases frequently makes no distinction between typhoid fever, bacillary dysentery and gastroenteritis; and, conversely, statistics on these diarrheal diseases frequently do not distinguish between the outbreaks which were transmitted by water and those transmitted by food and milk, by direct contact or by unknown vectors. The survey of nationwide statistics by Eliassen and Cummings (1) bears close scrutiny, therefore, because they have analyzed waterborne outbreaks to determine engineering factors which are of significance.

In general, it seems quite evident that the reduction in the incidence of typhoid fever represents the first major triumph in the environmental sanitation field. The great majority of public water supplies are of safe sanitary quality, as disclosed by the statistics under discussion. In fact, most of the current waterborne outbreaks are of gastroenteritis, occurring in summer resorts, institutions and the like, where technical control is lacking and where unsanitary

conditions prevail. Endemic typhoid fever is absent, but explosive epidemics due to temporary failures, which coincide with a period when the raw water supply is contaminated with *Salmonella typhosa*,* may still occur, but in greatly diminishing numbers. It is proposed to review experience in New York State to focus attention upon important aspects of this subject.

Summer Resort Water Supplies

The intensive supervision of New York summer resorts, which are occupied during the season by at least a million people, has resulted in the disclosure of many outbreaks of gastroenteritis which otherwise would have gone unnoticed. This fact explains why 66 per cent of the gastroenteritis outbreaks and 43 per cent of the apparent total of cases occurring in the country as a whole were reported from New York State during the period 1938–45 covered by the Eliassen and Cummings study. On the other hand, only 13 per cent of the outbreaks of typhoid fever, representing 6 per cent of the cases, were reported for New York State, which is approximately the average for that portion of the nation's population residing in the state. It would appear, therefore, that gastroenteritis may be prevalent throughout the country, although not reported from many states. Most such outbreaks in summer resorts are found to be due to unsanitary conditions resulting in the contamination of food. A smaller number are waterborne and are associated with water supplies which are far inferior to the great majority of public supplies and lack technical supervision. It is essential, therefore, for statistics on waterborne enteric diseases to be clarified in order to distinguish between public and private water supplies, and thus avoid erroneous conclusions regarding the status of the former.

Endemic Waterborne Disease Absent

The absence of endemic typhoid fever, bacillary dysentery and gastroenteritis in municipalities indicates that the usual day-to-day conditions surrounding public water supplies generally are satisfactory and that the present methods of water treatment are adequate. Otherwise, endemic enteric diseases would prevail in communities served by treated supplies from streams subject to heavy sewage pollution. On the other hand, the usual favorable conditions may be altered and explosive outbreaks may occur because of temporarily unfavorable conditions or accidents—failure of treatment equipment, structural failure incidental to floods, and the like—or because of human negligence, such as using an illegal cross connection between a potable and a polluted supply.

Gastroenteritis and Dysentery

Epidemic gastroenteritis now is the most prevalent enteric disease in New York State. Years ago this disease would occur several days after a water supply failure and was accepted as a forerunner of typhoid fever, so that little attention was directed to gastroenteritis itself. The successful control of typhoid fever, however, focused attention upon gastroenteritis. It was found that the remaining gastroenteritis cases frequently consisted of mild bacillary dysentery. Since 1938, however, there has been a gradual reduction in bacillary dysentery in New York State. For instance, only 47 isolated cases,

* This designation for the microorganism causing typhoid fever is preferred by *Bergey's Manual* (6th ed., 1948).—*Ed.*

with no deaths, occurred in 1948, none of which was waterborne.

The typhoid fever death rate in New York State for 1948 was negligible as only three deaths occurred from 44 isolated cases resulting from direct contact with carriers. Only 480 typhoid carriers are on record in New York State, exclusive of New York City, where it is reported that somewhat over 400 carriers are known to reside. This means that there are approximately 1,000 known carriers for a population of over 14,000,000. Using appropriate statistical technique, it is estimated that about 2,500 carriers may be residing among the upstate New York population of about 6,000,000. Under these conditions there is much less chance than formerly for sewage to be contaminated by *Salmonella typhosa*. Since more than one-half the carriers are over 60 years of age, many will die within a few years. This situation in turn modifies the probable ratio between the anticipated number of pathogenic organisms in polluted waters and the coliform index. Reference is made to the study by Kehr and Butterfield (*2*) for an evaluation of the relationship between the typhoid fever rates and the probable ratio between typhoid bacteria and coliform organisms in polluted raw waters. Although this subject is quite involved, the validity of the general relationship was corroborated by the morbidity data on the outbreak which occurred in 1940 in Rochester, N.Y. The opening of a valve on an illegal cross connection between a polluted fire supply and the municipal distribution system resulted in about 35,000 cases of gastroenteritis but in only six cases of typhoid fever. The untreated fire supply from the Genesee River was subject to sufficient sewage pollution to lead to a large number of cases of gastroenteritis, but only a few typhoid carriers on the watershed were contributing infectious material to the river at the time. Temporary failures in water supply systems, therefore, are much less likely to result in typhoid fever outbreaks than formerly. It is very evident that the supervision of carriers by health authorities is an important and economical approach to further reduction in typhoid fever, representing the first step in the chain of defenses, which consists of adequate sewage treatment and effective protection and treatment of water supplies.

Viruses

Gastroenteritis now prevalent in New York State among adults has been found to be associated with the absence of known pathogenic bacteria in appropriate stool specimens. An intensive study of this subject by Gordon, Ingraham and Korns (*3*) has disclosed that one or more viruses are involved in these outbreaks. Fecal filtrates, isolated from a gastroenteritis outbreak in an institution where direct contact was the vector, have infected human volunteers by the oral route, demonstrating that at least one filtrable virus was involved. The studies have not progressed to a point at which the transmission of such a virus by water, food or milk has been determined, nor is the resistance of the virus to heat or chlorine now known. It is pertinent to emphasize, however, that outbreaks of this character usually are associated with very unsanitary conditions, where the spread of the infection by direct contact is favored.

Tentatively it may be inferred that such a virus most likely is sensitive to the action of conventional doses of chlorine because, as noted above, gastroenteritis is not endemic in communi-

ties served by treated supplies from sewage-polluted streams. Final conclusions, however, must await further study.

Infant Diarrhea

Diarrhea among infants still remains an important cause of death in the age group under two. Bacterial pathogens infectious to adults are not associated with this illness. In other words, infant diarrhea occurs when unsanitary conditions in hospitals, nursing homes and the like provide an opportunity for the spread of infection by contact, and is not associated with public water supplies.

Engineering Aspects

An appraisal of the engineering aspects of this subject focuses attention upon the greater factor of safety now assured when coliform organisms are absent from delivered water, and, conversely, on the need for so designing, operating and supervising public water supply systems as to eliminate weak links which may fail during periods of stress and possibly lead to explosive outbreaks. There seems to be no one structural detail or type of equipment which is most susceptible to failure, granting that essential equipment is installed in duplicate.

Although the failure to protect ground water supplies or to treat supplies subject to pollution results in the majority of waterborne outbreaks at resorts, the few outbreaks associated with public water supplies are less easy to classify because of their low number and variety. No typhoid fever has been spread by public water supplies in the state since 1928, except for the Rochester outbreak in 1940.

Only four outbreaks of waterborne gastroenteritis due to public water supplies occurred during the period 1938–45, including the Rochester outbreak, which resulted in both gastroenteritis and typhoid fever. One other outbreak, attributed to "Seneca County," did not involve a public water supply as reported. Three of these outbreaks were associated with temporary lapses in effectiveness of chlorination, and the other with a cross connection. The one waterborne outbreak which occurred in the state in 1948 was the result of the unauthorized use of a new, small water supply system before the mains were disinfected. Every effort has been made to foster training programs, including wartime instruction in emergency measures and precautions in operation and supervision, which have a permanent peacetime value. Stress still must be placed upon the need for resourcefulness in promptly meeting emergencies, with forethought, planning and grasp of technical essentials as a basis. The human equation still remains the weakest link, as a skilled operator will secure acceptable results under unfavorable circumstances, whereas a negligent one may fail to use adequate facilities in a satisfactory manner.

In spite of the recent disclosure that one or more viruses may be responsible for waterborne gastroenteritis, the present standards of potable water quality seem to represent a satisfactory general guide when properly interpreted in the light of all factors affecting a given water supply, including the operating personnel. The inherent weakness associated with the latter probably represents the most serious challenge. Adequate salaries for water works personnel, operator training, and adequate budgeting for proper maintenance and supervision are essential to a more effective control

of water supplies. In fact, the lowered maintenance standards and delayed improvements in water supply systems incidental to the depression and the war years have created a serious situation which cannot be solved until public support is given to water rates adequate for needed repairs, expansion and maintenance.

Conclusions

It may be concluded that:

1. The present low number of carriers of typhoid fever is resulting in continually diminishing morbidity rates from this disease, as sewage is less and less likely to be infectious.

2. The current water pollution abatement programs should stimulate the treatment of sewage, which will still further reduce the chance of pathogenic organisms reaching water supply intakes.

3. Personnel training, with emphasis upon operating problems of maintaining water supply systems so as to avoid structural failures, temporary negligence and so forth, must continue to be stressed.

4. Water rates must be adequate to insure the employment of competent personnel and the provision of suitable facilities for delivering an adequate volume of water of safe sanitary quality under both usual and unusual conditions. The public must be made aware of its responsibility in supporting water pollution abatement programs and adequate water supply facilities in spite of the pressing demand for costly tax-supported projects in other fields.

5. Eternal vigilance, with confidence in available techniques shown by experience to be effective when properly applied, should be the watchword. Still further progress will come with improved application of current practice.

6. The point of diminishing returns for effort expended has been reached, so that future developments in water supply practices must be predicated upon broader grounds than water quality itself.

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The Alabama State Health Dept. is by no means satisfied with all phases of public water supply, nor does it feel that those engaged in actual operations are entirely satisfied, as demonstrated by their interest in the subject and by improvements made in the water works field from year to year. Such interest and improvement have not been due to the publication of material intended to excite the general public. Water works improvements with the end result of a better quality of water stem from the desire of those in the field to supply a product of the highest quality attainable. Possibly, water supply improvements can be obtained by the creation of doubt and fear in the mind of the public, but certainly no feeling of public confidence in water works officials can ever be developed and maintained by this means. In fact,

panic has sometimes occurred among the people when erroneous information concerning the community water supply was released through unauthorized sources. Occasional damage was done in that competent water works officials were dismissed.

The department has therefore adopted the policy of working strictly with water works officials in promoting improvements and has solicited the services of the press and radio only in emergencies such as floods and other disasters. In these few instances, the full cooperation of the press and the people has been obtained. It is not meant to imply, however, that water works operators are restricted in any way in promoting good public relations.

Factors Affecting Quality

This paper will take up the items in the Association questionnaire as they apply to Alabama.

1. *Inadequacy or lack of protection of ground water supplies.* In Alabama, 148 communities are dependent upon wells as sources of supplies. The majority of well supplies, located in the southern part of the state, take water below 300 ft. in sand and gravel. Practically all water from wells in southern Alabama is free of bacteria and is delivered direct from the well to the distribution system without chlorination. Where this direct transmission is interrupted, usually for corrective treatment, chlorination is required. Chlorination is also required when water is taken from springs and shallow formations. No diseases reported since 1923 have been traceable to a well supply. In general, it is felt that all of the well supplies are properly protected and are always delivering a safe water to consumers.

2. *Excessive pollution of surface sources of supply.* The sources of surface water supplies are not excessively polluted, with two exceptions which are to be corrected soon. In the meantime the operators know the existing conditions and are successfully handling the water by standard methods. All tests of bacteriological samples of the finished water at the plant and in the distribution system indicate a safe product.

3. *Inadequate treatment works for surface supplies.* It is a requirement in Alabama that all surface waters used as sources of public supply be adequately coagulated, settled, filtered and chlorinated before delivery to the distribution system. It is further required that all samples of filter effluents before postchlorination be of drinking water quality, considering both the plate count and tests for coliforms. A few small supplies do not have what are regarded as adequate treatment facilities, and some few plants are not in the best state of repair. Recently there were four filter plants operating over capacity (in excess of 2.0 gpm. per square foot of sand area). This situation has been corrected in all but one plant. It is hoped that the few plants not in the best of condition will fall in line in the near future. Samples from these supplies, however, indicate the delivery of a safe water.

4. *Failure to operate water purification systems properly.* With the exception of a few small communities, mining and mill villages, the department is confident that purification plants are satisfactorily operated. Water supplies are visited by department enginers from one to six times each year, and the equipment and operating procedures are thoroughly checked. The operators are given instructions during these visits. In addition, annual water works schools are sponsored by universities and the state health department. The interest in receiving

information on and demonstrations of water works operations is manifested by the large attendance at these schools.

5. *Pollution of water in the public distribution system.* Reports of bacteriological analyses made by department laboratories indicate that the water remains safe throughout the distribution system. Water works operators in the state realize the importance of maintaining a high-quality product. In past years contaminated water in distribution systems has been due chiefly to the installation of main extensions without proper cleaning and disinfection. Practically all mains laid today are disinfected and satisfactory reports of bacterial analyses are received before placing them in service.

6. *Pollution of water within domestic and industrial plumbing systems through back siphonage.* Five years ago the bacteriological samples collected from the distribution system of a small community were consistently positive for coliform bacteria. It was known that the well which was the source of supply was inadequate. Investigations revealed low pressures in the early evening due to failure to meet the demand. The condition reported was cleared up when an additional well was made. The conclusion, although not actually confirmed, was that back siphonage occurred during periods of low or no pressure in the system. So far as is known, no trouble from back siphonage has occurred elsewhere.

7. *Lack of recognition on the part of public officials for the need of trained personnel to operate water systems.* An excellent relationship is maintained with the majority of the municipal officials. It must be remembered, however, that the greater portion of Alabama communities have less than 2,500 people, and towns in this class cannot be expected to employ trained and experienced personnel. As they cannot afford it, it is necessary for engineers with the department to give the operators the requisite instructions for proper operation and also to instill in them a sense of responsibility.

8. *Incompetence or lack of training of water works personnel.* Although many operators are without academic training in water plant operation, it is surprising how well a high school graduate can learn, by experience and teaching on the job, to operate purification works. It is granted, however, that the men must be mechanically minded and receptive to instruction. Very few Alabama plants are operated by engineers or chemists. The results of this practice may be seen by examining the record itself.

Alabama Record

Public water supply operation was given very little attention in Alabama prior to 1918. Many towns and cities delivered raw surface waters directly to the distribution system without disinfection. Consumers of public water supplies were constantly reminded of the dangers of using water other than that taken from deep wells. The author does not believe that this situation was common only to Alabama; it was probably the same in many sections of the country. Very little thought is given by the general public to water supply today other than to its availability when needed. In fact, it is now found necessary to promote public relations programs to acquaint the people with the operations of their utilities.

In 1920 there were approximately 81 public water supplies in Alabama, serving approximately 28 per cent of the people. The majority of the supplies were in the larger cities and towns, very few communities of less than 1,000

having access to supervised public supplies. In the same year there were 361 recorded deaths due to typhoid fever and 835 deaths of children under two and 227 deaths of people over that age due to diarrhea and enteritis.

The records show that there are now 310 communities with public water supplies, serving approximately 50 per cent of the state's population. There were only 6 deaths in 1948 due to typhoid fever and 147 deaths of children under two and 28 deaths of persons over that age from diarrhea and enteritis.

It is not assumed that the operation of public water supplies in Alabama is solely responsible for reducing the typhoid and enteritis death rates 98 and 82 per cent, respectively, but it is felt that the water industry played a leading part. With one exception, which some writers persist in publicizing unduly, there has not been an outbreak of any disease traceable to a public water supply since 1923. The water supply has often been named as the causative agent at the outset, but has been exonerated when all the epidemiological data were analyzed.

As previously stated, the department is not satisfied with all phases of water works design, construction and operation, and there are many problems which have not yet been solved completely. Great progress has been made in the water works field in the past years, but the industry should not be content to rest upon its laurels.

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The author would like to present at this time a revision of Florida's reply to the August 1948 Association questionnaire.

1. *Inadequacy or lack of protection of ground water supplies.* Like other states which have considerable areas of limestone upland, Florida has problems in the protection of ground water supplies. In sinkhole terranes, percolating ground waters are not well filtered. The natural hazard is greatly increased by the construction of drainage wells, creating direct short circuits between surface sources and deep-seated aquifers. Of course, the real hazard lies in the popular fallacy that all deep well water is virgin pure, but deep aquifers in limestone outcrop regions must be protected on the surface. Until surface sanitation is adequate, protection of exposed subartesian aquifers is lacking. This is a great problem and its attack calls for controls and education. Florida faces a growing danger of salt intrusion along its coastline. This question, however, is more truly one of wise development, protection and conservation than of inadequate protection alone.

2. *Excessive pollution of surface sources of supply.* Those surface waters which are developed directly for potable supplies in Florida are rather well isolated from excessive pollution. Furthermore, over 90 per cent of the connections are served from wells. It must be reemphasized, however, that the pollution of surface waters which recharge permeable limestones is cause for concern, as is the complacent attitude toward pollution on the part of some laymen, officials and even technicians.

3. *Inadequate treatment works for surface supplies.* Treatment works for surface supplies are adequate insofar as equipment is concerned, with the exception of two very small systems. The latter use supplies which are disinfected and are derived from protected sources, but the operators are now being sub-

jected to strong suasion for additional treatment. It is the policy of the Florida State Health Dept. to permit no surface water supply without adequate treatment. which does not include merely chlorination.

4. *Failure to operate water purification systems properly.* Improper operation is a problem the author would put near the top of the list. Too many splendidly adequate treatment works, in Florida and elsewhere, have depreciated to the classification of junk in a few years. Ten or twelve years of neglect and incompetent operation can ruin the finest plant.

5. *Pollution of water in the distribution system.* Cross connections between unsafe supplies and the mains of approved distribution systems pose a continuing problem for all. The danger from this source is more often seen in the smaller towns, but also exists in the larger cities in lake regions. It will be interesting to learn the results of a cross connection survey being made in a city where possibly 5 per cent of the residential units have separate irrigation systems using raw lake water.

Recently a case of chronic main contamination was remedied with a Stillson wrench. One water superintendent who thought his gate valves had failed found a cross connection giving him questionable water at a rate of nearly 50 gpm. Failure to promote safe chlorine residuals throughout the distribution system invites trouble. In another city, newly laid mains are not sterilized, flushing being considered sufficient to eliminate gross contamination. It is to be wondered how many other superintendents follow only this procedure. These matters should be kept in mind when taking stock of the location and frequency of sampling, which must be adequate to insure safety.

6. *Pollution of water within domestic and industrial plumbing systems through back siphonage.* Florida's program has not developed enough to make a worth-while contribution to a discussion of back siphonage.

7. *Lack of recognition on the part of public officials for the need of trained personnel to operate water systems.* Florida's second major problem may well be the attitude among officials that a plant operator need be only a passable mechanic, able to turn valves, grease pumps and fit pipe. Quality must somehow take care of itself. It is not surprising to observe that often the operator's attitude toward his responsibility for the public health is a true reflection of the attitude of his superiors toward him. The active desire to serve safe water is lacking; the interest is not there.

It is axiomatic that goods will flow to a ready market as surely as water flows downhill, and more positive and direct action probably could be taken to work out internship arrangements for college seniors and graduate students with municipalities and utilities. Until there is created among officials a sincere demand for excellence of operation, a full attack cannot be made on the problem of proper personnel training which is inseparable from this one.

8. *Incompetence or lack of training of water works personnel.* In Florida, the opportunity for and the intensity of training have increased greatly in the past few years through the annual short course at the University of Florida and the regional short courses around the state. The short courses have been improved by providing five days of bacteriology and chemistry, graded from elementary to advanced study under A. P. Black and other outstanding men.

Although the schooling has improved, it is felt that the basic training

of many of the men is not adequate to serve the needs of the plants. It is also sadly true that the absentees from the short courses are those men who need the training most. Some who would come cannot, because their superiors do not care to send them or finance the trip. This again demonstrates the fact that failure to sell the need for competent operators means failure to open fully the way to improve the training of the incompetent and the untrained.

Inadequate Operating Budget

The common failure to include an adequate sum for operation in the financial structure of water works requires comment. In Florida, this matter is aggravated by a constitutional amendment exempting homesteads from ad valorem taxation. There is a tendency to siphon off water service receipts into municipal general funds. It is not an infrequent practice to milk a water system up to the very limit of minimum operation and the obligated balances imposed by bondholders. Accordingly, it is gratifying that one major investment banking concern will henceforth stipulate in bonding covenants and ordinances that the financial structure include sufficient funds for good operation and maintenance (so that adequately trained men can be employed).

An adequate operating budget is a matter of concern to the bond buyers, who are beginning to realize that good operation protects their investment just as directly as it affects the public health. It would be fine to have every municipal water works bonding ordinance include such an obligation, but unfortunately at present there is usually no such guarantee.

Sewage Pollution

The author believes that the water works industry would do itself and the public interest a great injustice if it played down the real menace of sewage pollution. Because the best of the industry believes itself nearly above reproach, can it foster a general belief that the industry includes no fringes to be ashamed of? Can the industry in good conscience say it harbors no situations where only good fortune has prevented disaster? These questions must be answered frankly and with a clear conscience before a complacent attitude can be condoned, let alone fostered. The water industry must not take the position of saying that, since supplies are mostly good and treatment and control mostly adequate, there will be no waterborne disease.

The epidemiologists' report of a waterborne typhoid epidemic not far from Florida a few years ago also raises the question whether all outbreaks are reported. One fatality led to the discovery that either the dilution of *Salmonella typhosa*, the prevalence of vaccination or the weakness of the strain had caused an epidemic that conceivably could have escaped detection. As it was, only searching investigation in the laboratory disclosed its scope, for most of the victims never knew what their trouble had been. This incident bears a double warning, for it involved sewage pollution reaching a deep limestone aquifer, as well as inadequate treatment—the incompetent-operation factor is not reported but was probably present.

The Florida health department has been criticized for frank, factual replies to inquiries from the press. It is sensitive to the unwarranted and unfair national publicity given prob-

lems on which it is making progress, but the department refuses to gloss over or cover up any potential hazard —even if one or more factors necessary to create an epidemic are not yet present. As a regulatory agency, it must answer to all the people, although it would like to be in the position to say always: "Yes, you can drink your water in complete safety."

Conclusion

The author agrees with A. D. Weston that the time is near, or at hand, when there should be an inventory of those engaged in water works practice —those in the sanitary engineering profession, those in a regulatory status and laboratory personnel. Furthermore, it is necessary for the industry to evaluate its attitude toward the U.S. Public Health Service Standards. Are these standards to be used as a criterion for universal application; or is the industry going to wait, attempt to hold its own and let time prove whether or not it still has public health problems?

The author believes he can safely say that Florida has gone a long way but can make further progress. In the author's opinion, on the basis of facts available for other sections of the United States, the general answer would be very much the same. The water works industry in Florida has cause for pride in its record of no reported waterborne epidemic since 1919. Many plants and personnel are excellent, and the critical comments made apply only to the minority. But the presence of this minority serves to destroy any sense of smug satisfaction.

As the standards are raised for the safety of the people, the industry should recognize and attempt to use them in a practical way. High standards, after all, are only a practical measure of what ability and equipment can do. They are the industry's par for the course.

Everyone concerned in the water industry—the superintendent, the operator, the public official, the consulting engineer and the regulatory agency —must work toward a common understanding and uniform approach to the standards that will serve the best interests of all. The only factor on which compromise is impossible is the public interest—that is, the public health.

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A public health engineer welcomes any discussion on water quality, even though he has not found a satisfactory definition of that phrase. Only experience and judgment can really evaluate water quality in terms of the health and comfort of the consumer. The drinking water standards set up a measuring device to judge the quality of water for use on interstate carriers. Many states have adopted these standards, but what do they really certify or define? The present mode of living—and especially travel—makes it impossible to trace the source of illness. The fact that many gastrointestinal disturbances are not reported likewise, perhaps, protects water supplies, which could have been the source of infection.

In the author's opinion, the so-called standards are not to be used as a goal but as a means toward a goal. It is known that *Escherichia coli* and *Aerobacter aerogenes* are bacteria associated with filth and therefore have no place in drinking water. Why satisfy cer-

tain standards by allowing a given percentage of samples to be contaminated and do nothing just because the contamination is below allowable limits?

In water quality the best is not too good. Therefore, the best possible product should be developed, even though it exceeds accepted minimum standards. Thus, in developing a ground water supply, a site will not be approved unless it is the best one available from the standpoint of possible pollution and contamination. The same policy holds true for equipment.

The matter of operation likewise comes in for severe criticism. Operators are not producing the best water possible with the equipment they have on hand. Sometimes the governing body does not hire an operator equal to the plant. At present there are water works operators who were painters, carpenters, diesel operators and—in a few plants—plumbers, an appointment regarded with pride.

Again, the matter of protection can be criticized. The goodwill obtained by permitting cross connections with private supplies outweighs, it appears, the dangers allied therewith.

Many water plants have a chlorinating machine in their list of equipment, but, like the family Bible, it is there for display and seldom used—sometimes not until samples show contamination repeatedly. Even though the yearly average might be within the so-called limits, one questions the actual quality.

In the matter of surface supplies, there is now a race between pollution and purification. It is true that water plants settle, treat, filter, chlorinate and store the polluted and contaminated water from streams and make a product that is accepted as drinking water. Is the drinking water quality raised by devising new and better techniques to treat a water often approaching sewage? Perhaps some attention should be paid to developing a better raw water by working with sewage treatment programs. As a parallel, Nebraska's quality milk program only succeeded when it was realized that the raw product or source must be improved. Therefore, the water works man must be extremely active in stream pollution abatement.

Undoubtedly, the water works operator is cognizant of his plant's weaknesses and faults, and it is indeed embarrassing for health department representatives to be continuously pointing out the potential hazards. It is more pleasant to give compliments but, since the health and comfort of the people are at stake, the goodwill of the operator and the goodwill of the council or board of public works perhaps will have to be strained. Facts must be faced. Are the water plants producing the best quality of water available? What effort has been made to live up to the confidence the public is placing in water works men by assigning them the job of supplying the most essential commodity of life?

Use of Radio by Water Departments

By Carl A. Hechmer, Adolph Damiano, Frank E. Dolson and Nathan S. Bubbis

A panel discussion presented on June 2, 1949, at the Annual Conference, Chicago, by Carl A. Hechmer, Dept. Engr., Maint. & Operation Dept., Washington Suburban San. Dist., Hyattsville, Md.; Adolph Damiano, Distr. Engr., Hackensack Water Co., Weehawken, N.J.; Frank E. Dolson, Distr. Engr., St. Louis County Water Co., St. Louis, Mo.; and Nathan S. Bubbis, Acting Gen. Mgr., Greater Winnipeg Water Dist., Winnipeg, Man.

Application for FCC License—*Carl A. Hechmer*

THE first step suggested for those desiring to acquire and operate radio equipment is to obtain a set of the new FCC industrial radio service rules (1) effective July 1, 1949.

Assignment of frequency must first be accomplished through the Regional Frequency Assignment Coordinating Committee of the National Committee for Utilities Radio. The purpose and function of this committee is covered by Adolph Damiano (*see* p. 893) and needs no further discussion here. It should be realized, however, that these committees consist predominantly of electric power company men and, unless the water industry takes an increased interest in this subject, it is to be expected that the more desirable frequency channels will be exhausted by others. However, the recent appointment of an A.W.W.A. member on each of the regional committees tends to eliminate this possibility and assures the water works of its rightful place in the frequency assignment pattern.

An application must be filed with the FCC for a construction permit, Form 401-*c*, for the land or central broadcast station, giving specific data on the location of the land station, antenna structure and location of the nearest airport. If the antenna and supporting structures exceed an overall height of 150 ft. above ground level, or if the site is within 3 miles of an airport, another application form, 401-*a*, must accompany the construction permit application. This form must include a sketch showing the antenna and supporting structure and a map showing the location of the antenna with respect to airports. The frequency assignment letter from the regional coordinating committee should accompany the construction permit application.

Approval of the construction permit will permit purchase and installation of the necessary equipment. Manufacturers of radio equipment of this type will be found most helpful in selecting the proper kind, and it is possible to draw up specifications to permit several manufacturers to bid on the equipment.

A separate application form must be submitted to cover the mobile sets to be used. The proposed sets must be

described and the number to be placed in service must be stated.

Following purchase and installation, an application for a license to operate must be made to the FCC on Form 403. The license is usually granted as soon as tests are completed to assure that the installation has been made in accordance with the original construction permit and that no unforeseen circumstance has arisen which might prevent proper operation without interference in other radio activities.

Restricted phone permits must be obtained for all operators of the land or base station, but none is necessary for the mobile unit or field operators. The base station operator, however, is responsible for the mobile operator's use of the radio system and must see that it is confined to proper channels.

Repair, maintenance and adjustment of either base or mobile units require the services of a first- or second-class radiotelephone operator. Such classifications are obtainable from the FCC at Washington or at any of the regional offices by satisfactorily passing the necessary examinations. Restricted operator's licenses are also obtained from the FCC regional offices upon submission of necessary evidence of citizenship, intelligence and knowledge of the rules of the air.

Sanitary District Radio

A log must be kept at the base station of all calls put on the air, for review by the FCC if requested. In the Washington Suburban Sanitary Dist. operations, monthly reports are made up of the calls, to aid in evaluating the advantages of radio operation.

At present the district has 24 mobile sets in service and one base station. The latter is located in the main office at Hyattsville, Md., while the antenna is on the Glenmont elevated water tank 10 miles away (airline distance), a leased telephone line connecting the two. Radio is used not only for emergency calls to the various trucks and cars but also for ordinary water and sewer department business, such as giving the location of valves and manholes to the men in the field, ordering materials and equipment and conducting general departmental affairs. Personal calls are not permitted, although messages to the office when men are delayed in the field are sometimes relayed to their homes by telephone, if necessary.

Since the district's station is in the 30–40-mc. frequency band (actually, 37.7 mc.), some interference is encountered from other stations presumably on the same wave band. This condition has also been noted by other participants in this panel, which confirms the desirability of getting into the higher frequency assignments. The interference is not serious, since operation of the district's own equipment blanks it out, but it is annoying at times to hear other messages going back and forth when the receiver should be quiet. The district station has heard and communicated with stations at Prosser, Wash.; Lewiston, Va.; Blythe, Calif.; Wichita and Arkansas City, Kans.; and Winnipeg, Canada; and has logged their call letters and identified the utilities operating them.

Reference

1. Rules Governing Industrial Radio Services. Docket No. 9018, Federal Communications Commission, Washington, D.C. (1949); *requests for copies should be addressed to Secretary, Federal Communications Commission, Washington, D.C.*

Selecting FM Equipment—*Adolph Damiano*

This paper will not dwell on the electrical or mechanical details and features of FM communication equipment nor discuss the specifications or costs of such units. This information can be readily obtained from manufacturers of radio communication systems. Such organizations as Motorola, Inc., Link Radio Corp., General Electric Co., Western Electric Co., Radio Corp. of America, Federal Telephone & Radio Corp. and others will not only be pleased to mail technical specifications and descriptive literature on their most modern equipment, but, upon request, will promptly and eagerly send their representative to review individual requirements, to plan a communication system and to submit cost figures without any obligation or expense to the prospective customer. All of these radio manufacturers are producing transmitting and receiving apparatus particularly suitable for water utility requirements and applications.

FM, or frequency-modulated, radio is steadily becoming established as the superior medium of sound broadcasting. The public is rapidly coming to appreciate the better reception offered by FM, its virtual freedom from static and other forms of interference and its realistic and high-fidelity reproduction of sound. AM—amplitude-modulated—radio, which has been in use since the introduction of the vacuum tube, will gradually be relegated to a minor role and perhaps in time be entirely replaced.

In the AM system, the carrier wave is continuous and has the signal superimposed upon it. The effect of the signal, which employs a current of moderate radio frequency, is to contract or expand the amplitude in varying degrees according to the intensity of the signal. In the FM process, it is the frequency of the carrier wave that is varied by the impressed signal. FM transmissions are made in the regions of ultrashort waves of the spectrum.

Primary Considerations

In determining or selecting the proper combination of equipment for any installation, certain fundamental or major factors must be considered.

There are three basic communication systems:

1. The one-way system, in which a fixed land station transmitter provides instant contact with one or more mobile stations which have no talkback facilities. The operator of the vehicle will either proceed with the detail signified by the signal or seek a nearby telephone to reach his office or supervisor for further instructions.

2. The two-way system, in which the land station and the mobile stations are able to communicate immediately with one another. This is perhaps the most dependable and best adapted system of communication.

3. The three-way system, in which contact between the mobile stations is provided in addition to the normal two-way service. Two-frequency operation is used when car-to-car communication must not interfere with the fixed station.

The type of system selected will depend entirely upon the specific requirements and the service to be rendered.

Municipal and private water departments have been classified by the FCC in the Power Utility Group, including

private and municipal electric power companies and cooperatives, manufactured and natural gas companies, and steam companies. Committee 4, Panel 13 of the Radio Technical Planning Board, now known as the National Committee for Utilities Radio, comprising representatives of the various utilities mentioned, has for a number of years aided the FCC in the postwar planning of frequency allocations and in preparing system standards for the radio services.

The Power Utility Radio Service has been placed by the FCC in the classification of Industrial Radio Service, consolidating a number of existing classes of service, such as geophysical, provisional, motion picture, relay press, power utility and petroleum pipeline.

After several years of deliberations, engineering conferences, hearings and the presentation of voluminous testimony and data by interested groups and services, the FCC announced, in the May 6, 1949, issue of the *Federal Register,* the final frequency allocations for the various services. The Power Radio Service has received blocks of channels in the following parts of the spectrum: 25–50-mc., 72–76-mc., 152–162-mc. and 450–460-mc. bands. For reference purposes, a list of the various frequencies so allocated will be found in Appendix B.

It must be emphasized that the frequency assignments made up to now are to be considered temporary. As a result of the FCC announcement of frequency allocations, it will be necessary for some systems to be modified for operation on a different frequency than the one assigned. This change may entail an expenditure for new crystals, and antenna and equipment adjustments. More information about expiration dates and shifts to other frequencies will be forthcoming.

On May 6, 1949, the FCC issued Docket No. 9018, promulgating new rules governing industrial radio services, which became effective July 1, 1949.

Through the effort and sponsorship of the National Committee for Utilities Radio, ten regional radio groups have been formulated and established. A representative of the A.W.W.A. has been designated on each of these groups to present the requirements and interests of the water works industry in the respective areas of the country and also to act as a liaison between the regional groups and the water works sections. A list of such geographical sections and the name of the A.W.W.A. representative for each area is included in Appendix A and Fig. 1 (*see* pp. 904–5).

In determining or selecting frequency assignments, the reader is strongly urged to avail himself of the services of the regional frequency coordinating committees. The group committees are cooperating with a similar National Power Utility Frequency Coordinating Committee in evolving a national plan of frequency distribution as well as a regional scheme of channel assignments of the frequencies allocated by the FCC for use by the Power Radio Service. These plans are being worked out so that interference between systems can be kept to a minimum. The demand for channel space is so great that maximum and effective utilization of the radio spectrum must be made. In fact, the problem is so important that several manufacturers are conducting research and investigation toward perfecting the design of equipment for operation in the same area on

adjacent channels. This improvement would have the effect of increasing the available usable channels by eliminating the need for guard bands.

Selection of Frequency

In selecting a frequency or wave length, several considerations must be entertained, such as the size of the area to be covered or the range desired, the nature of the terrain and the height of the available antenna sites. Generally speaking, the lower the frequency the greater the interference due to ionospheric reflection, often referred to as "skip" or "sky wave" interference. For a given range, more power output is required on the lower frequencies than on the higher ones.

The range to be expected in the 30–50-mc. band is greater than at the higher frequencies. Frequencies in the 152–162-mc. band, however, will offer satisfactory transmission within their range, especially in the large cities having tall buildings and congested areas. Nevertheless, serious consideration should be given to the utilization of channels in the higher-frequency bands in flat, open country. To minimize skip interference in the 30–50-mc. band, it is advisable to use the least power and antenna height that will provide adequate coverage. High antennas are generally required for greater range of communication, both for sending and receiving. Increased transmitter power will increase the sending range of equipment. Locating an antenna on a high hill or mountain to obtain optimum coverage is desirable if it is within reasonable distance from the dispatching headquarters. Provisions must then be made for remote control of the equipment by radio or wire.

In choosing a frequency or channel, care must be taken to insure that no other local station is being operated on the same or on an adjacent channel. The best way to avoid this possibly troublesome interference situation is to consult the frequency coordinating committee of the appropriate regional utility group for its recommendation before making a final selection.

Equipment

The latest types of radio communication equipment are made compact, with a single chassis for transmitter, receiver and power supply. This design has become necessary because of the importance of space on all types of vehicles. Newly developed miniature tubes and components make it possible to construct these units in smaller size. As a result of this trend, space is saved and initial cost and installation time and expense are kept at a minimum.

One of the newest innovations in modern equipment is selective calling. By this means, a station may, by operating a telephone dial, call any one or any preselected group of stations in the system without alerting the other stations not being called. The dialing of the number will cause a bell to ring, a lamp to light, a horn to blow or a combination of these signals, thus attracting the attention of the occupant of the vehicle.

Another new element in modern equipment is a variable "squelch" which can be adjusted to reduce annoyance from foreign signals and thus obtain optimum reception. In this manner, finger control is available for squelch performance, to keep the receiver quiet when the "carrier" is not on.

The selection of equipment is very important since poorly constructed units will radiate spurious energy and respond to systems assigned to other channels, resulting in poor service and wasted channel space. Before reaching a decision on the equipment to be purchased, there should be some assurance that it will reflect the best standards of radio engineering, have the highest level of selectivity and stability, and give trouble-free, stable and reliable service.

Service companies are gradually being formed to maintain and service radio communication systems so that there is no necessity for the user to set up a special department for this purpose.

Although the above remarks have placed emphasis on mobile radio systems, considerable usage of radio is anticipated for telemetering, supervisory control and voice communication.

Conclusion

There is no need to recite the many benefits of mobile radio. Radio communication offers the only practical, fast, safe means of maintaining contact with inspection and repair crews for restoring facilities and service and for preserving life and property in emergencies. From the standpoint of improving public relations and promoting service to the customers, radio's opportunities are unsurpassed.

Radio-Wire Service—*Frank E. Dolson*

The postwar cost of labor and material coupled with a prewar rate structure alerts management to the possibility of savings by the use of newly developed operational aids. More than ever, water engineers and superintendents must be aggressive in their search for ways by which better service can be rendered at reduced labor and material costs. Other utilities, with rate increases in mind, are actively reducing expenses when possible and are competing for consumer goodwill by employing advertising and all other means at their disposal. The water industry can do no less, since it, too, is often faced with the need for more revenue. The uphill grade to rate increases can be lessened, to a great extent, by solid consumer goodwill.

Radio is a new, postwar tool for water works. Its use by all utilities has become extensive, and there is no question that radio enables its users to solve and correct emergencies expediently in addition to dispatching routine work more efficiently.

Radio service, at present, is available in three ways: [1] an independent system in which the owner makes the capital investment and maintains and operates the system; [2] community ownership or a facilities-rental agreement; and [3] a combination radio-wire service on a subscription basis from a common carrier.

Types 1 and 2 are exclusive radio services, the only difference between them being arrangements regarding ownership, maintenance and the like. The preference depends upon the economics in each specific instance.

Radio-wire service, commonly known as radiotelephone service, is unique for the reason that it utilizes both radio and telephone facilities. It is a service offered for a monthly charge by a common carrier, which owns and main-

tains all equipment. Charges to the subscribers include an equipment rental fee in addition to a service charge.

Four types of such service are available: general, dispatching, signaling and highway.

General Service

In general service, messages are transmitted by familiar telephone outlets and wire to a centrally located transmitter. From this point, the message is transmitted to the mobile unit directly by air. Messages from the mobile units are transmitted by air to auxiliary receivers maintained at strategic locations in the urban area. (These auxiliary receivers can usually be recognized by small antennas on top of long telephone poles.) From that point, the message is transmitted to a central station by wire and thence through regular telephone facilities to a telephone outlet.

The main transmitters at the central station have a 250-w. output and an effective range of 20 miles. The mobile units are equipped with 30-w. transmitters having a correspondingly smaller range. The auxiliary receivers and wire transmission are necessary to enable the mobile unit to transmit messages to the central station from anywhere within the 20-mile service area. Very few blind spots exist and these can usually be overcome by moving the mobile unit a short distance.

Each channel within the assigned 152–162-mc. band will service a maximum of 65 mobile units. The present practice, in the St. Louis area at least, is to limit the number of mobile units per channel to about 50. Since channel overloading with resultant delays in message transmission would defeat the purpose of the service, the telephone company constantly surveys each channel for evidence of overloading.

The service is available to anyone who cares to subscribe. Taxicab companies, newspapers and truckers are using it along with the utilities. As there are no priorities on messages, the service can be compared to party line telephone service in which the availability of the equipment is solely dependent upon the facilities being free of usage by other subscribers. Less essential subscribers are privileged to tie up the channel so that utility emergency messages are subordinated to casual or routine ones. In any comparison between radio and radiotelephone, the lack of priorities in the latter system should be considered.

There is a considerable difference between radiotelephone service and radio in the method of usage. Usually in independently owned systems, a dispatcher is in constant contact with all mobile units. A transmitted message is received by all mobile-unit operators who are near their sets. Operators must be near their vehicles and listening to all calls.

By contrast, radiotelephone service has the advantage of selective ringing. Each of the approximately 50 mobile units assigned to a single band is given a numerical designation. The mobile-service operator, who can be reached through any telephone outlet simply by dialing or asking for long distance, can signal each mobile unit on the channel on a selective basis. The signal received by the mobile unit is an audible buzz, or, if preferred, required switches and relays can be installed, at additional cost, so that the mobile operator is called by a horn. If the operator happens to be outside the range of the two signaling devices, he is notified that

he has been called by an indicating light.

Selective signaling is one of the real advantages of radiotelephone service. It enables a workman to range far away from his equipment with perfect assurance that he can hear his call signal. This feature is particularly advantageous for a foreman who is required to supervise construction or maintenance work remote from his vehicle. The horn can be heard over a considerable distance and is usually above the noise level of the nearby work.

Another advantage of radiotelephone service is the fact that supervisory personnel can contact mobile units directly from the office or home by using the ordinary telephone outlet. The convenience of this feature should appeal to superintendents, engineers and others who are subject to calls on weekends and at night.

Calls originating from the mobile unit are handled in much the same manner as by regular telephone service. The mobile-service operator is contacted and connections to telephone outlets are made in the usual way.

Other Types

Dispatching, signaling and highway services are merely variations of the general service. Usage is similar in each method, although differences do exist in the equipment, service and costs.

Dispatching service is identical with general service except that a dispatching telephone outlet is provided at a designated location. The dispatching outlet is connected directly to the central station, thus eliminating the need for calling or dialing long distance.

Signaling service is a limited arrangement under which mobile units can be

TABLE 1

Rental, Service and Message Charges

	General Service	Dispatching Service	Signaling Service
Zone	Principal*	Principal*	Any
Dispatching phone		$3.00 per month	
Rate			
Principal to mobile	30¢ first 3 minutes 10¢ each additional minute	15¢ first minute 15¢ each additional minute	10¢ per signal
Mobile to mobile	40¢ first 3 minutes 10¢ each additional minute	40¢ first 3 minutes 10¢ each additional minute	
Minimum service charge			
First unit	$7.00 per month†	$7.00 per month	$5.00 per month§
Each additional unit		$2.50 per month‡	$2.00 per month§
Equipment charge	$15.00 per month	$15.00 per month	$7.00 per month
Minimum monthly charge			
One unit	$22.00	$25.00	$12.00
Two units	$44.00	$42.50	$21.00

* Zones other than principal have different message rates.
† 20 free 3-minute calls per month, per unit, from mobile station only.
‡ 40 free 1-minute calls for first unit and 10 free 1-minute calls for each additional unit. These calls may originate from either the mobile unit or the dispatching phone and will be grouped for the purpose of the service charge.
§ 40 free signals per month first unit, 10 free signals per month each additional unit.

notified by a light indicator to call, by other means, a designated location. No talkback service is provided nor can outgoing calls be made over the channel.

Highway service, currently in the 35–45-mc. band, differs from the others in that it is available along certain highway routes and is not confined to urban areas. It has little place in the water utility field, except perhaps in rare instances when such service is closely adjacent to long supply lines or impounded storage.

TABLE 2

Dispatching Service Costs *

	Yearly	Monthly
Minimum charges (including equipment, service and dispatching terminal)	$876.46	$73.01
Usage		
Allowable for service charge	720 min.	60 min.
Excess above allowable	1,651 min.	137+min.
Excess-usage charge	$296.85	$24.74
Total charges	$1,173.31	$97.75

* These figures are for one dispatching terminal and three mobile units, and include all applicable taxes.

Minor vehicle alterations are necessary to provide adequate power to the mobile telephone unit. The equipment requires 7–8 amp. in standby or ready-to-receive service and 35–40 amp. while transmitting. Under normal operating conditions, current demand of this magnitude will rapidly deplete the usual storage battery. Car modification usually consists of replacing the battery with one of 200-amp-hr. capacity and substituting a police type generator for the existing one. The cost of these changes is nominal, being approximately $30 for the battery and $60–$85 for a heavy-duty generator capable of a 12–15-amp. output at idling speeds and 35–45 amp. at 10–15 mph.

Sometimes a more expensive generating system is used, consisting of an a-c. generator in conjunction with a rectifier and voltage regulator. Its output is approximately 30 amp. at idling speeds and 60 amp. at motor speeds of 1,150 rpm. or above. This system is useful on slow-speed vehicles or on those of limited travel.

TABLE 3

Breakdown of Calls

Purpose	Calls per Year
Reporting in, giving and receiving job orders	797
Ordering material	196
Consumer service and complaints	383
Valve operation	104
Total	1,480
Average Cost per Call	
Minimum charge	$0.592
Excess-usage charge	0.201
Total	$0.793
Average duration per call	1.6 min.

Costs

The capital expense per installation may be summarized thus:

Unit charge for installing radio equipment in vehicle	$25.00*
200-amp-hr. battery	30.00
Police type generator	75.00
Total	$130.00

* $12.50 for signaling equipment.

Rental, service and message charges are given in Table 1 for general, dispatching and signaling services. Since these services are of the toll variety,

it may be of some interest to detail the usage and cost experience of the St. Louis County Water Co. in a recent twelve-month period. Dispatching type service (one dispatching terminal and three mobile units) was selected as the source of the data in Table 2.

A total of 1,480 calls was made during the year from both the dispatching terminal and the mobile units. A breakdown of these calls and the average cost per call are shown in Table 3.

An average cost of $0.79 for each conversation of 1.6 minutes' duration appears, at first glance, to be excessive. There are attendant savings, however, which, though difficult to evaluate, are real and will reduce the average cost to a much smaller figure. Aside from the fact that the entire cost of the service could be paid for by the savings resulting from the prompt handling of a single emergency, other routine savings can be expected. Some of these are: [1] less standby time for crews receiving new orders; [2] faster and more accurate material deliveries; [3] better dispatching, which results in more efficient use of labor; and [4] reduced telephone expense.

It can be concluded that mobile radio has demonstrated its usefulness in the operation of water systems. Radiotelephone service merits consideration as a satisfactory alternate for independent systems.

Winnipeg Experience With Radio—*Nathan S. Bubbis*

Winnipeg, Man., possibly on account of its geographical location, has been very radio conscious. In April 1931 it became the first city in Canada to adopt a system of radio communication for its police vehicles. This one-way system from a central station to the vehicles was operated by the City Signals Dept., which also operates the city's fire and police telephone and signal systems.

It was not long before the Water Works Operating Dept. saw the advantages that could be derived from the use of radio, and arrangements were made with the signals department in February 1934 for the installation of a radio receiver in the water works emergency truck. The method of operation was for instructions to be telephoned to the signals department, which then relayed them to the emergency crew. In 1939 the system was changed to two-way communication on a frequency of 40.5 mc. Following the progress made during the war and the development of FM, the police department in 1946 obtained a frequency of 30.7 mc. in the 38-mc. band, and two-way FM communication was established. This equipment was also installed in the water works emergency truck, but all messages still had to be relayed through the signals department.

Experience with this limited radio service convinced the water department that it should obtain a radio channel and a station of its own. In September 1946, on departmental recommendation, the Committee on Public Utilities authorized an application for a channel and a call for bids to set up a system of two-way FM radio communication. A considerable amount of difficulty was encountered with the Federal Dept. of Transport, which has jurisdiction over radio communication in Canada. The Winnipeg Fire Dept. had also applied for an independent station at about the same time, and it was

only after a good deal of correspondence and representation to Ottawa that a frequency of 153.83 mc. was finally assigned in favor of the fire department to operate a joint service with the water department. After further discussion, it was agreed to operate jointly for a period of six months, at which time the situation was to be reviewed.

Water department specifications called for the construction of a 100-ft. radio tower and the supply and installation of one central station unit and seven mobile units. The fire department asked bids on a tower, central station and six units. Because of government regulations and a shortage of material, the equipment was not placed in service until October 1947.

Radio communication is of current interest to water works superintendents and properly so, although, in the author's opinion, its true worth has not yet been fully recognized, certainly not to the same extent as in other utilities. The Winnipeg water department has received numerous inquiries on its system, and the main point always boils down to whether the expenditure on radio has been justified. Winnipeg's answer is a definite affirmative. The original installation expense of the 100-ft. tower, one station unit and seven mobile units was about $6,000. It now costs about $600 to equip a vehicle. The department's radio equipment is maintained by the signals department, which has personnel trained for this work. Although the station has been in use only for about a year and a half, it is estimated that the operating costs will not exceed $600 annually. The life of the equipment is estimated to be at least seven years.

Benefits of Radio

It is fairly simple to arrive at the cost of installing and maintaining a radio system, but it is most difficult to evaluate the service derived from it in dollars and cents. Frequently time saved by the use of radio in controlling one bad leak in the commercial area of a city will save damage to property amounting to more than the capital cost of the radio equipment.

A few examples will illustrate some of the benefits derived from radio communication.

1. *Contact.* The office can keep in touch with the foremen and they in turn can maintain contact with their crews, no matter where they are in the city. The following timetable will serve to demonstrate the truth of this observation:

9:16—Office received telephone report of leak at Walnut and Westminster Sts.

9:17—Office radioed message to the emergency crew to investigate the leak. This message was also picked up by the leak tester, who, being in the vicinity, proceeded to the location and started testing for the leak.

9:35—Emergency reported that the leak was bad, the residents had been notified and the main shut off. Emergency requested that the water main foreman be notified to begin repairs as soon as he could get a crew to the spot.

9:36—Dispatcher reported the leak to the foreman, who requested that No. 9 Truck go to Renfrew St., pick up the crew there and move them to Walnut and Westminster Sts. He also asked that the leak tester be notified.

9:37—Radio message sent to No. 9 Truck to pick up and move crew from

Renfrew to Walnut; acknowledgment received.

9:39—Radio message to the leak tester confirmed the fact that he was at the location testing for the leak; foreman notified.

9:50—Leak tester was able to report that he had located the leak.

10:01—Men moved from Renfrew St. by No. 9 Truck arrived at Walnut and Westminster and were prepared to begin work on the leak.

In less than 45 minutes from the time the report of the leak was received, the complaint was investigated, the customers were notified to draw a supply of water, the leak was located, the main was shut off and the crew of men and their equipment had been moved a distance of several miles from a routine job and were ready to start repairs. Without the use of radio, this shift would probably not have been made until three hours later, the broken water main would have been out of service for a longer period of time and the men would have had to work a considerable overtime period to complete the repair —at overtime rates of pay.

2. *Availability of records.* Because Winnipeg has up to 7 ft. of frost in the normal winter, its water mains are located at least 8 ft. below grade. In excavating in frozen ground, it is essential that great care be taken to avoid cutting into the other underground utilities, such as telephone ducts and high-voltage power lines. When a foreman is in doubt, the underground records are available to him if he just lifts his receiver and calls the dispatcher in the office. This advantage applies also to the location of valves on street lines which may be difficult to locate.

3. *Communication after regular hours.* Radio is particularly valuable between 10 o'clock in the evening and 8 o'clock in the morning, when other forms of communication are not available.

4. *Public relations.* Recently a lead service pipe entering a basement cracked off just at floor level, the water running over the basement floor and alarming the householder. Not having a phone of her own, she went to the corner store and called the water department. The dispatcher immediately radioed the meterman and instructed him to turn off the water at the stopcock. He happened to be driving down the adjoining street when he received this call and promptly pulled up in front of the house with the broken service. By the time the woman had returned from the corner store, he was operating the stopcock in front of the house. She was naturally amazed at the speed with which her complaint had been acted upon. It is not possible to evaluate this particular service in dollars and cents, but there can be no question that it builds up good customer relationships.

Employee Attitude

It is interesting to note the attitude of water works employees toward radio. When the department first installed two-way radio in most of its trucks, the reaction of the men was very unfavorable. They had the feeling that radios were being placed in their vehicles to give management the opportunity of continually checking their movements. This feeling of suspicion was dispelled in very short order, however. The men now rely on their radio to such an extent that, on the infrequent occasion when the sets are out of order or have to be removed for

servicing, the complaints from individual foremen or supervisors are loud and insistent until the units have been replaced.

Radio communication has likewise been most useful in the work of the Sewer Maintenance Div., which is operated jointly with the water works. In emergencies, the sewer department's trouble truck can be dispatched to the scene immediately, which makes it possible to prevent basements from being flooded and to take immediate action on the discovery of gasoline leaks in sewers.

Use in Emergencies

Radio communication really shows its true worth under emergency conditions. In April and May 1948, during the spring breakup, the worst flood since 1916 occurred. The rivers rose about 18 ft. above normal summer elevation, causing areas of the city and surrounding municipalities to be flooded. Dikes had to be erected, sewers had to be plugged and often pumped, and the department's labor forces and equipment were spread out very thinly. The radio system was found to be so valuable that two sets were flown in from Montreal. They were installed in about 48 hours from the time that they were ordered and rendered invaluable service during the floods.

Since the original installation has proved as successful as had been hoped, additional mobile units have been added until there are now eighteen mobile units in service, fourteen in the water department, one in sewer maintenance and three in the engineering department. Eventually there will be at least 25–30 radio-equipped trucks in the whole department. The city has been rapidly expanding, but it is hoped that radio will reduce the amount of useless traveling to such an extent that it will not be necessary to place additional trucks in service. It will certainly reduce the number of vehicles which would otherwise be required.

A little trouble was experienced in maintaining the equipment, but modifications made at the factory have cleared up most of the difficulties and, on the whole, communication has been very satisfactory. In spite of representations made to the Federal Dept. of Transport, the water department is still operating its station jointly with the fire department. Joint operation has not been too inconvenient under present conditions and has sometimes been an asset. Both central stations are linked through the city overhead signal system, and the equipment is so arranged that either department can broadcast over its own or over the other's station. Thus, if there is trouble on either station, a flip of the switch permits continued broadcasting. It will ultimately be necessary, however, to obtain an individual channel in order to handle the increased amount of traffic.

Winnipeg is definitely of the opinion that two-way radio communication has proved very successful. It has speeded up the work of the department considerably, resulting in more economical operation and better service to the community.

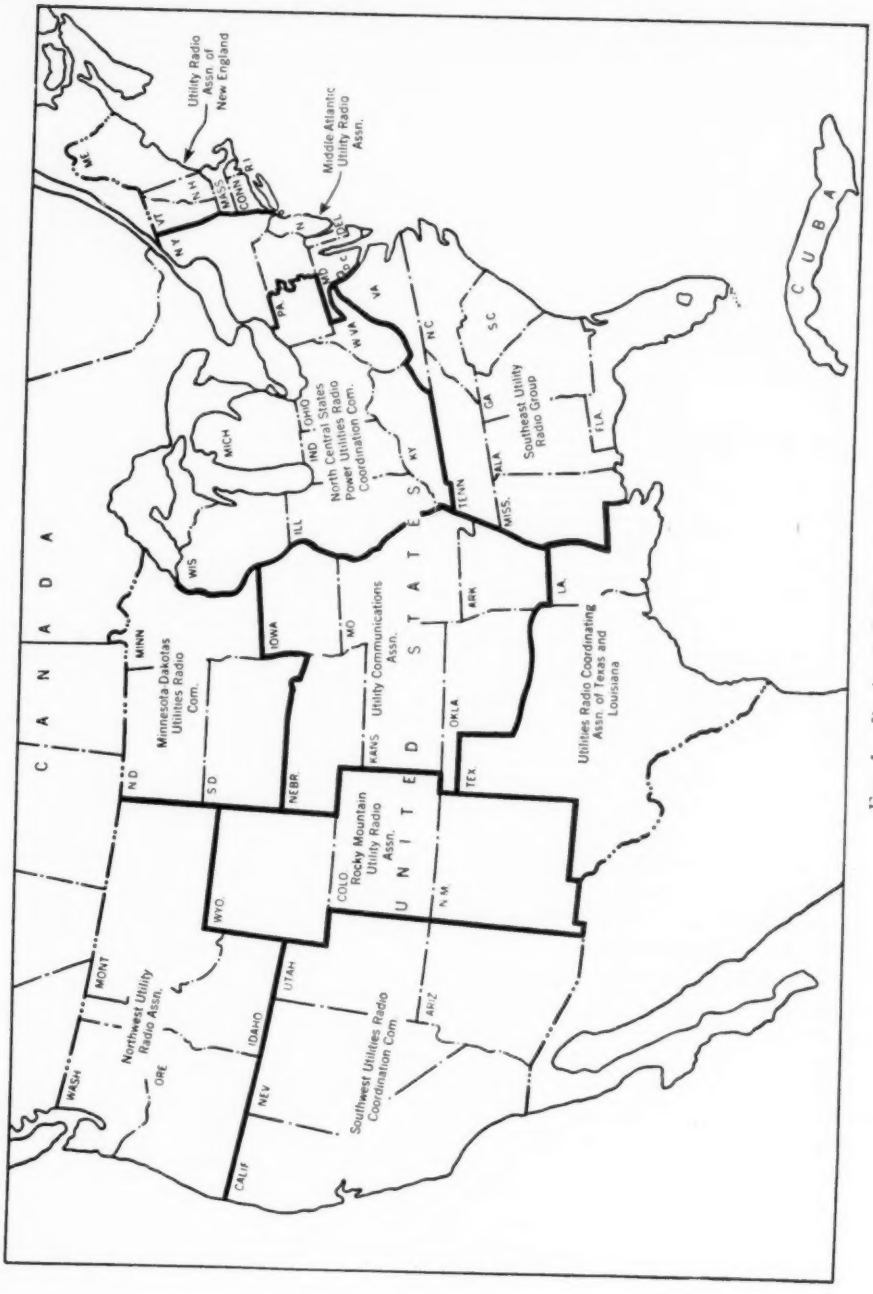

FIG. 1. Regional Radio Groups

APPENDIX A

National Committee for Utilities Radio Regional Coordinating Organizations

1. *Utility Radio Assn. of New England*

J. H. Hanly *
Blackstone Valley Gas & Elec. Co.
55 High Street
Pawtucket, R.I.

2. *Middle Atlantic Utility Radio Assn.*

H. N. Ekdall *
Philadelphia Elec. Co.
672 Public Ledger Bldg.
Philadelphia, Pa.

Adolph Damiano,† Distr. Engr.
Hackensack Water Co.
4100 Park Ave.
Weehawken, N.J.

3. *Great Lakes Utilities Radio Committee*

H. D. Ashlock *
Public Service Co. of Indiana, Inc.
110 N. Illinois St.
Indianapolis, Ind.

H. W. Niemeyer,† Supt. of Distr.
Indianapolis Water Co.
113 Monument Circle
Indianapolis 6, Ind.

4. *Mid-Central Utilities Radio Committee*

Lee O'Dell *
Kansas City Power & Light Co.
1330 Baltimore Ave.
Kansas City, Mo.

M. P. Hatcher,† Director
Water Dept.
City Hall
Kansas City 6, Mo.

5. *Southeast Utility Radio Group*

V. R. Parrack *
Florida Power Corp.
St. Petersburg, Fla.

Paul Weir,† Gen. Mgr.
Water Dept.
1210 Hemphill Ave., N.W.
Atlanta, Ga.

6. *Utilities Radio Coordinating Assn. of Texas and Louisiana*

M. W. McRaven *
Houston Lighting & Power Co.
Electric Bldg.
Houston, Tex.

Albert R. Davis,† Supt.
Water Dept.
Austin 4, Tex.

7. *Southwest Committee for Utilities Radio*

G. E. Bishop *
Coast Counties Gas & Elec. Co.
22 Pacific Ave.
Santa Cruz, Calif.

H. A. Knudsen,† Mgr.
Mech. and Elec. Div.
East Bay Munic. Utility Dist.
512—16th St.
Oakland 4, Calif.

8. *Northwest Utility Radio Assn.*

L. G. Walker *
Idaho Power Co.
1220 Idaho St.
Boise, Idaho

J. Guy Eernisse,† Mech. Engr.
Water Div.
402 City Hall
Tacoma, Wash.

9. *Minnesota-Dakotas Utilities Radio Committee*

H. A. Schimelpfenig,* Mgr.
Minnesota Valley Elec. Cooperative
Jordan, Minn.

H. G. Tischer,† Mgr.
Water, Gas & Sewage Disposal Dept.
414—16 W. 1st St.
Duluth 2, Minn.

10. *Rocky Mountain Utility Radio Assn.*

L. F. Hayworth *
Southern Colorado Power Co.
Pueblo, Colo.

George J. Turre,† San. Engr.
Board of Water Commissioners
Box 629
Denver 2, Colo.

* Secretary.
† A.W.W.A. representative.

APPENDIX B

Power Radio Service Frequencies

Base and Mobile Stations

The following frequencies are available for assignment to base and mobile stations in the Power Radio Service only:

mc.	*mc.*	*mc.*	*mc.*
37.46	47.70	48.14	153.41
37.50	47.74	48.18	153.47
37.54	47.78	48.22	153.53
37.58	47.82	48.26	153.59
37.62	47.86	48.30	153.65
37.66	47.90	48.34	153.71
37.70	47.94	48.38	158.13
37.74	47.98	48.42	158.19
37.78	48.02	48.46	158.25
37.82	48.06	48.50	
37.86	48.10	48.54	

The following frequencies are available for assignment to base and mobile stations in the Power Radio Service on a shared basis with other services: 2,292 kc.,* 4,637.5 kc.,* † 35.06 mc.,‡ 35.10 mc.,‡ 35.14 mc.‡ and 35.18 mc.‡

The following frequencies are available for assignment to base and mobile stations in the Power Radio Service on a shared basis with other services under the terms of a developmental grant only:

mc.	*mc.*	*mc.*	*mc.*
456.05	456.55	457.05	457.55
456.15	456.65	457.15	457.65
456.25	456.75	457.25	457.75
456.35	456.85	457.35	457.85
456.45	456.95	457.45	457.95

Frequencies in the following bands are available for assignment to base and mobile stations in the Power Radio Service on a shared basis with other services, under the terms of a developmental grant only; the exact frequency and the authorized band width will be specified in the authorization: 2,450–2,500 mc.,§ 3,500–3,700 mc., 6,425–6,575 mc. and 11,700–12,200 mc.

Subject to the condition that no harmful interference will be caused to reception of television channel No. 4 or 5, the following frequencies are available for assignment to fixed stations in the Power Radio Service on a shared basis with other services:

mc.	*mc.*	*mc.*	*mc.*
72.02	72.82	73.62	74.42
72.06	72.86	73.66	74.46
72.10	72.90	73.70	74.50
72.14	72.94	73.74	74.54
72.18	72.98	73.78	74.58
72.22	73.02	73.82	75.42
72.26	73.06	73.86	75.46
72.30	73.10	73.90	75.50
72.34	73.14	73.94	75.54
72.39	73.18	73.98	75.58
72.42	73.22	74.02	75.62
72.46	73.26	74.06	75.66
72.50	73.30	74.10	75.70
72.54	73.34	74.14	75.74
72.58	73.38	74.18	75.78
72.62	73.42	74.22	75.82
72.66	73.46	74.26	75.86
72.70	73.50	74.30	75.90
72.74	73.54	74.34	75.94
72.78	73.58	74.38	75.98

Fixed Stations

Frequencies in the following bands are available for assignment to fixed stations in the Power Radio Service on a shared basis with other services, under the terms of a developmental grant only; the exact frequency and the authorized band width will be specified in the authorization: 952–960 mc., 1,850–1,990 mc., 2,110–2,200 mc., 2,450–2,500 mc.,‖ 6,575–6,875 mc., 12,200–12,700 mc., 16,000–18,000 mc.‖ and 26,000–30,000 mc.

* This frequency may be subject to change when the Atlantic City table of frequency allocations below 27.5 mc. comes into force.

† This frequency is limited to daytime use only, with a maximum plate power input to the final radio frequency stage not to exceed 100 w.

‡ The use of these frequencies by stations in the Power Radio Service is subject to causing no harmful interference to the Maritime Mobile Service.

§ Use of frequencies in the band 2,450–2,500 mc. is subject to no protection from interference due to the operation of industrial, scientific and medical devices on the frequency 2,450 mc.

‖ Use of frequencies in the bands 2,450–2,500 mc. and 17,850–18,000 mc. is subject to no protection from interference due to the operation of industrial, scientific and medical devices on the frequencies 2,450 mc. and 18,000 mc.

Insurance Protection for Municipal Water Departments

By Charles G. Bourgin and Elmer C. Schwier

A panel discussion presented on May 30, 1949, at the Annual Conference, Chicago, by Charles G. Bourgin, Supt. & Engr., Water Bureau, Montclair, N.J., and Elmer C. Schwier, Secy.-Treas. & Controller, Indianapolis Water Co., Indianapolis, Ind.

Types of Insurance Protection—*Charles G. Bourgin*

IN the construction, operation, maintenance and repair of any water system, perhaps the most common causes of property damage and bodily injury arise from water system construction and water main leaks causing undermining.

Attitudes of Operators

Since the presentation of a previous paper by the author on this subject (1), many inquiries have been received for information on experiences with insurance coverage for this type of damage. From the character of these inquiries, the author was impressed by the widely divergent opinions and attitudes entertained by the operators of many publicly owned water systems toward acknowledging liability not only for damage caused by leaks but for damage resulting from general water works construction. These opinions and attitudes divide the operators into four general classifications:

1. *Operators who have never given any thought to insurance protection or who are totally unaware that such protection is available.* The dangers involved in this "head-in-the-sand" way of thinking—or, more accurately, lack of thinking—are self-evident in this day and age of insurance policies and lawsuits, and require no further discussion.

2. *Operators who entertain the fallacious opinion that a publicly owned water system is a governmental function and, as such, is immune from suit, thus eliminating the need for insurance protection.* It is a well established fact that municipal operation of a water system is not a governmental function like the operation of a police or fire department, but is strictly a proprietary or business function whether or not it operates at a profit. The general legal opinion throughout the nation is that, when a municipality engages in a proprietary enterprise, it makes itself liable to the same extent as any private corporation. In other words, when negligence appears, legal liability follows with resultant exposure to damage suits whether the proprietary operation is publicly or privately conducted.

3. *Operators who have given consideration to insurance protection but who have decided for one reason or another not to carry it.* In general, these men have weighed the risks and have decided that it is more economical not to carry the protection. They feel

that the total of all damage claims which may have to be paid over a period of years would be materially less than the cost of insurance premiums over the same period. Some of these operators actually set up a reserve or self-insurance fund, deposits in which are based on estimated premiums for public liability and property damage insurance for their class and size of operation. These deposits continue to be made yearly until the fund has reached an amount sufficient to provide a reasonable degree of security. In the event of a loss, systematic deposits to the fund are resumed until it again reaches the agreed-upon safe level. Other water works pay small damage claims from operations budgets and draw on surplus or reserve funds to meet the larger claims.

Many efficient operators in this class use the best of accepted water works practices in all phases of construction, operation, maintenance and repair. They thus depend upon being able to produce good records, render prompt action in emergencies and display other evidences of good management, so that it becomes extremely difficult for a claimant to prove negligence. Many notable cases are a matter of record in which claims were not allowed by the courts because the water utility, by proving that it consistently operated in a safe and efficient manner, made it difficult, if not impossible, for the claimant to prove negligence. There are also a few operators in this class who rely solely on the influence of municipal ownership to make it hard or awkward for a claimant to prove negligence regardless of the validity of the claim.

Everyone is familiar with the attitude of many insurance companies toward the ready payment of small claims, whether valid or not, chiefly because of their nuisance value. The reverse attitude, however, is generally true of all self-insured operators who display great resistance to the payment of any claim, large or small, which may often work a severe hardship on an honest claimant.

In the author's opinion, although self-insurance programs have real merit—particularly for the larger water utilities, whose insurance premiums would run high for complete public liability and property damage coverage—there is a limit to the size of a claim beyond which self-insurance does not offer adequate protection. It is believed that these operators would do well to carry some form of catastrophe or excessive-loss coverage, which may be obtained at a materially lower premium than that for the same top limits for complete coverage.

4. *Operators who carry public liability and property damage insurance protection in one form or another.* The operators in this class fall into two general groups: [1] those who carry full insurance protection for all claims, large and small; and [2] those who self-insure up to certain limits, usually $5,000–$10,000 aggregate, and then carry excessive-loss insurance to cover the larger claims. Upper limits for both complete coverage and excessive-loss coverage for public liability generally range between $50,000–$200,000 for each person and $100,000–$500,000 aggregate, while those for property damage generally range between $50,000–$100,000 for a single accident and $100,000–$200,000 aggregate.

Types of Coverage

Policies providing these coverages are called contractors' or manufactur-

ers' liability policies and are usually comprehensive in scope—that is, they cover all public liability and property damage risks such as are found in every phase of water works construction, operation, maintenance and repair (including special rates for masonry and concrete construction, carpentry, electrical wiring, plumbing, painting and decorating, if desired). Premiums are computed on the size of classified yearly payrolls. Occasionally, however, when protection against claims arising from water quality is desired as an added feature, premiums for this coverage are based on the quantity of water supplied yearly to the system. This type of coverage, known as manufacturers' products liability insurance, is rarely offered without the addition of the more desirable (to the insurance company) public liability and property damage business. In determining the advance premium, estimates of the coming year's payroll or amount of water to be supplied to the system are made, based on the previous year's experience. These estimates are corrected at the end of the year by payroll audit or examination of water supply records, and the premium is readjusted for final payment or rebate. Premium rates are generally based on the previous five-year experience record of the utility to be insured. When catastrophe or excessive-loss coverage is carried, year-end rebates as high as 15 per cent are enjoyed if no claims have occurred. From these facts, it may be noted that rates are affected by actual claims experience records and that the cost of identical coverage varies with the size of the payroll or quantity of water supplied to the system, depending upon which method of premium computation is used.

Illustrative Cases

The following cases illustrate two ways in which damage claims against a publicly owned water utility carrying contractors' liability insurance were settled. Further examples may be found in a previously published paper (1) already cited.

Case 1. *Damage to other than municipal property, involving bodily injury resulting from a main break.* A large pipe fracture occurred about noon in a 12-in. main under 110-psi. pressure. This main, located in the heart of the business district, had been laid parallel to the curb and under the center of a 10-ft. wide sidewalk running between the curb and the building walls. Extensive damage was done to the sidewalk and the contents of several basements but none to the municipal pavement. A woman was drenched and slightly injured when the break occurred. All claims were covered by contractors' liability insurance, including those for the injury to the woman and the damage to her clothing.

Case 2. *Property damage involving bodily injury as a result of construction, but not the fault of the utility.* A 20-in. main was being installed under a sidewalk around both sides of a corner property. The property consisted of two lots completely grassed over except for the area occupied by a residence which was located on the lot adjacent to the corner lot. The entire property was surrounded by a barberry hedge about 3 ft. high. The open trench, containing newly laid pipe, completely surrounded the entire street frontage of this property. Sidewalk approaches had been thoroughly barricaded, excavated material 5 ft. high lined the curb and the work was more than amply lighted, as later agreed on by all concerned. Access to a post-

mounted corner mailbox had been provided by a well lighted bridge equipped with guard rails. It remained, however, for a neighbor up the street to enter the corner lot via backyards, cross the lawn on private property and leap the barberry hedge near the mailbox as he had done many times before when mailing a letter late at night. Too late he discovered, upon striking the pipe and trench side approximately 6 ft. down, that the sidewalk had been removed. Although acknowledging his error in this rather unorthodox and entirely illegal approach to the mailbox, he registered a claim for back injuries and clothing damage. The insurance company paid both the public liability and property damage claims, even though the fault lay entirely with the claimant. The total claim was not particularly large but probably represented a nuisance value to the insurance company.

Conclusion

Because, in the opinion of the courts, there is no material difference between public and private ownership of a water utility when responsibility for public liability and property damage claims is concerned, every water utility should carry some form of contractors' liability insurance to protect itself from serious losses arising from these claims. The larger utilities perhaps do well at least to carry catastrophe or excessive-loss coverage in conjunction with budgetary provisions for self-insurance coverage for the smaller claims; the smaller utilities might better carry complete coverage. The choice between excessive-loss coverage and complete coverage must be determined from a study of the size of the premium (based on payroll or quantity of water supplied, whichever method is selected), as well as a review of the claims experience record of the particular utility in question. It is also to be noted that operating in a negligent manner is expensive, even though adequate public liability and property damage insurance is carried, since premium rates are based on experience records.

Reference

1. Bourgin, Charles G. Liability for Damage Due to Breaks or Leaks—Undermining Due to Leaks. Jour. A.W.W.A., **40**:579 (June 1948).

Nuisance Claims—*Elmer C. Schwier*

This paper will discuss insurance protection against so-called "nuisance" claims, particularly injuries which involve curb boxes, meter pits, valve boxes and fire hydrants.

Any concern which must deal with the general public, such as a department store or theater, is subject to claims for injuries received on company property. This liability also applies to public utilities, in their general offices, in plants where the public is permitted to enter and in the large number of other items of property either owned or maintained by the utility and located over the entire area served.

In Indianapolis, Ind., the water company does not own service lines or curb boxes, but an agreement was made between the company and the Public Service Commission of Indiana in 1930 to the effect that the company would be responsible for the maintenance and upkeep of service lines, including curb boxes, from the main to the property line; on April 1, 1932, by order of the Public Service Commission of Indiana, this agreement was made permanent,

thus making the company responsible even though it does not own the curb box.

Causes of Accidents

A summary of accidents over the past eighteen years (1931–48, inclusive) indicates that curb boxes were involved in 57 claims filed. From these claims, it appears that it is not always necessary for a curb box to extend several inches above the ground level for someone to trip over it, although it has often been hard to imagine how anyone could have fallen over the box designated as the culprit. Nor is it necessary for these boxes to be located in sidewalks ordinarily used by the public. Sometimes it would seem that persons have gone completely out of their way to trip over boxes that were nowhere near the sidewalk—in fact, several feet away. On numerous occasions the accident occurred in the early evening, and quite frequently there were no witnesses.

Meter Pit Accidents

The next item on the list is meter pits, concerning which 41 claims were filed during the eighteen-year period mentioned. Meter pits are located on private property and are not owned by the company. However, if someone—even the property owner himself—trips over a meter pit and is injured, a claim is filed with the company. Since these pits are not the property of the company, and since it is not held responsible for their maintenance and upkeep, it is not required to pay damages on very many of these claims. The only time the company becomes seriously involved in a meter pit claim is when a meter reader has visited the premises either on the day of the accident or a few days prior to it; on such occasions the question arises whether or not he fastened the lid securely after reading the meter.

Claims due to accidents involving valve boxes in the street and fire hydrants totaled only nine during this eighteen-year period. The number of claims is comparatively insignificant, but as both of these items are the property of the company, it can be held liable.

All together, 107 "nuisance" claims were filed during the eighteen-year period, 1931–48.

Trend of Claims

The last depression started in 1930 and ran through 1940, with the exception of a slight upturn in 1937 and in the latter part of 1939 and the early part of 1940, and the present boom began early in 1941. With these facts in mind, the author has divided the eighteen-year period into six-year intervals. It was found that 11 claims involving curb boxes were filed in the first six-year period, 1931–36; 37 claims, between 1937 and 1942; and 9 claims, between 1943 and 1948.

During the first six-year period, 5 claims regarding meter pits were received; during the next period, 14 claims; and during the last, 22 claims. Meter pit installations have increased over the past several years, which accounts for the increase in claims in the most recent period.

There were 5 claims involving valve boxes and fire hydrants in the first period, 2 in the second and 2 in the third.

Whether or not the depression had anything to do with the number of claims the author is unable to say, but it does seem odd that most of them were filed in the years toward the end of the depression, and they have since dropped

off to a considerable extent, with the exception of meter pit claims.

In 1941 Indianapolis began a program of adjusting curb boxes to grade and by the end of 1942 had covered the entire area served. Since then meter readers have submitted reports on curb boxes in bad condition, which are turned over to the distribution department for adjustment. In this way, the utility keeps up fairly well with curb box maintenance. This program may have had some effect on the reduction of claims after 1941. At the same time meter readers report pits that are in dangerous condition. A letter is written to the property owner advising him that the meter pit belongs to him and that steps should be taken immediately to repair it and avoid the possibility of someone's being injured.

Need for Insurance

The majority of these claims cases are not of a serious nature. Some have been settled for as little as $15.00, while a few others have developed into litigation proceedings and the claimants have been awarded several thousand dollars. Although the amount of money involved is usually not large, every accident must be investigated and a report made to the insurance company, and practically the same preparation is required as if the accident were a serious one. This procedure can become expensive.

In the Indianapolis system, there are approximately 114,500 curb boxes, 17,000 meter pits, 7,847 fire hydrants and 8,500 valve boxes located over the area served. A total of 107 accidents over an eighteen-year period does not seem large, compared to the total number of curb boxes, meter pits, hydrants and valve boxes, but one must not overlook the fact that each of these items is a potential hazard. Moreover, when a claim is filed, it is never known in advance whether it will be settled for $15.00 or for several thousand dollars. Some apparently insignificant claims have later developed into rather expensive cases.

For these reasons, the author does not believe that the Indianapolis Water Co. can afford to be without adequate insurance protection, particularly considering the many possibilities which the large service area provides for the general public to sustain injuries. The utility carries public liability insurance with limits of $100,000 to $1,000,000. The insurance companies have been very cooperative in discussing each claim before settlement is made, an important point since the amount paid out in claims affects the experience rating on which the premium is based.

This Month's Cover

The term "upstream engineering" has been applied to the channel stabilization and flow retardation measures exemplified by the floodwater detention structure near Mapleton, Iowa, shown in the cover photograph (reproduced through the courtesy of the U.S. Soil Conservation Service). As Carl B. Brown points out (p. 923), small engineering works of this type play an equal part with proper land use in the control of sediment production in watersheds.

Effect of Land Use on Reservoir Siltation

By H. E. Hudson Jr., Carl B. Brown, Harry B. Shaw and J. S. Longwell

A panel discussion presented on June 3, 1949, at the Annual Conference, Chicago, by H. E. Hudson Jr., Head, Eng. Subdiv., State Water Survey Div., Urbana, Ill.; Carl B. Brown, Sedimentation Specialist, Soil Conservation Service, U.S. Dept of Agriculture, Washington, D.C.; Harry B. Shaw, Deputy Chief Engr., Washington Suburban San. Dist., Hyattsville, Md.; and J. S. Longwell, Chief Engr. & Gen. Mgr., East Bay Municipal Utility Dist., Oakland, Calif.

Problem of Reservoir Siltation—*H. E. Hudson Jr.*

RESERVOIR sedimentation has taken most water works men unawares. Twenty-five years ago the existence of the problem was barely recognized. Today, through the occurrence of destruction of reservoir storage, the matter is being brought forcibly to the industry's attention. Sedimentation generally takes place at the inlet and in the bottom of the reservoir and is frequently not noticed until full use of storage capacity is necessary, when the loss of storage becomes apparent.

Present trends in land use increase the removal of soil from the land by rainfall and runoff, causing increased turbidity and correspondingly greater difficulty in water treatment plant operation. A worsening of the present trend may lead to a situation in which, as Abel Wolman has put it, the problem will not be to take the silt out of the water but to wring enough water out of the silt.

The central figure in studies of reservoir sedimentation in America is Carl B. Brown of the U.S. Soil Conservation Service. He has been engaged in sedimentation studies throughout the nation and has prepared a number of authoritative publications on the subject. In previous papers before this Association he has called attention to the factors involved in control of reservoir silting and to methods of control of erosion on watershed lands. These articles are standard references for use in studies of reservoir damage by siltation. Persons familiar with the recent books by Fairfield Osborn (1) and William Vogt (2) will recall that they prophesy the conflict between man's needs for food and fiber and his misuse or exhaustion of the land. These writers underscore the relation between land use and water resources.

Illinois has available approximately 600 sites for water supply reservoirs. The state now has 500 lakes and reservoirs, nearly half of the natural water storage facilities being in use. It is time to think of the future of the remaining locations where water can be stored economically.

At today's prices, to construct a typical water supply reservoir on a natural site may cost about $500 per million gallons of storage. It is not

at all uncommon to find rates of destruction of storage facilities in Illinois so great that the cost is about one-tenth of the water bill paid by each family. This figure is not large when considered in relation to annual income, but since sites for storage are limited, the rate of destruction is such that the storage capacity may be inadequate for the expected population in only a few lifetimes.

Illinois Survey Program

The Illinois Water Survey Div. has cooperated in fourteen surveys of sediment deposit in reservoirs in the past fifteen years. One-fourth of these studies have revealed damage to the lakes sufficient to necessitate immediate consideration of additional facilities.

Illinois studies of reservoir sedimentation are carried out by cooperative agreement between the State Water Survey Div. of the Dept. of Registration and Education, the U.S. Soil Conservation Service and the University of Illinois Agricultural Experiment Station. Under this agreement, the State Water Survey Div. provides field men for the actual physical survey, prepares the basic reports and compiles, edits and publishes the completed report. The Soil Conservation Service furnishes surveying equipment and aerial photographs for field work, provides technical instruction and guidance in the conduct of the surveys, and reviews the reports. The Soil Conservation Service has given additional aid through the conduct of soil conservation surveys of the watershed lands. The Agricultural Experiment Station has prepared the land use studies and carried out the analyses of sediment samples taken from the reservoirs.

In 1936 surveys of sediment deposits were carried on cooperatively by these three agencies on four lakes in Illinois. In 1946 Lake Decatur was resurveyed. Surveys were made of six smaller lakes in Illinois in 1947, and in 1948 Lake Bloomington and Lake Springfield, two larger lakes, were surveyed. Less complete reconnaissance studies have been made by the Soil Conservation Service of a number of other lakes in the state during this period.

The program of surveys in Illinois is designed to measure the effects of the factors that influence the rate of sedimentation of Illinois reservoirs. Reservoirs chosen for surveys are carefully selected so as to be representative of existing and future projects.

In carrying out this work, the maximum of local cooperation is encouraged. The owners of the lake are expected to furnish a number of laborers for clearing, operation of boats and the many other minor tasks involved.

Factors Involved

The soils of Illinois vary greatly. They range from the sandy, permeable soils of the Kankakee Marshes to the tight clay hardpan along the southwest edge of the state. The State Soil Survey considers that there are twelve major categories of soils and 83 soil groups, each of which may include a number of specific soil types. These vary in erodibility and in permeability, so that each acts differently in its contribution of sediment to reservoirs.

Although Illinois is normally considered a prairie state, every reservoir site must of necessity be located in a deeply dissected valley to make dam construction economical. Therefore, the slopes involved in a study are likely to be moderately steep. There is considerable variation in this respect throughout the state. For example, at

Decatur, 93 per cent of the land was level or gently sloping, while at Carbondale, only 18 per cent of the land was that flat.

The runoff from the land depends primarily on the rainfall and the soil permeability. It varies from a comparatively low figure in the north to a much higher figure in the extreme southern portion of Illinois. These variations in rates of runoff affect the transportation of the sediment.

One of the most startling facts brought out by the surveys carried on to date is that reservoir design engineers have not known how to take into account the sedimentation that will occur. A simple parameter to measure this effect is the storage capacity–watershed area ratio, which expresses the volume of storage provided per unit of watershed area. The units are generally acre-feet per square mile of watershed. A low ratio will usually point toward a rapid rate of filling of the reservoir with sediment, and a higher one will usually indicate a lower rate of damage. Lake Calhoun, at Galva, and Spring Lake, at Macomb, with capacity-watershed ratios below 25, are losing 4.4 and 2.3 per cent, respectively, of their storage capacity annually, while Lake West Frankfort and Carbondale Lake, whose ratios exceed 285, lost less than 0.8 per cent of their capacity annually.

Another important factor in this connection is the size of the watershed. In a very large watershed, it is obvious that the distance to be traveled by sediment will be great. There are therefore many opportunities for the sediment to deposit between the point of erosion and the reservoir. For this reason, there is correspondingly less sediment damage to reservoirs on large watersheds than on small ones. It is this factor that explains the great difference in damage between Lake Decatur and Spring Lake at Macomb. Both have approximately equal capacity-watershed ratios, but the percentage loss of capacity is twice as great on the 20–square mile watershed of Spring Lake as on the 900–square mile watershed of Lake Decatur.

By far the most significant factor brought out in the Illinois sedimentation studies has been the effect of land use on reservoir sedimentation, as demonstrated by the Decatur studies, where a 20 per cent increase in the rate of sedimentation was found for the period 1936–46 as compared with the preceding 14.2 years (*see* p. 921). Subsequent surveys have qualitatively confirmed the findings of these studies.

Throughout Illinois there are indications that increasingly intensive use is being made of the land. Steep lands that should be in forest are being cultivated. Sloping lands that should be under crop rotation, contour farming or strip cropping are being plowed up and down the slope. In one square mile of land, 600 of the 640 acres were plowed up- and downhill with intertilled row crops. Treating the land in such a fashion not only fritters away the farmer's capital but simultaneously destroys water supply reservoirs.

The nation is faced with a growing threat to its surface water resources and its land. The means to avert this threat are available, and some of them will be discussed by other members of this panel.

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Watershed Control—*Carl B. Brown*

The membership of the Association has a very real concern in taking steps to lessen the creeping paralysis that sedimentation is imposing on the water storage facilities of so many municipalities throughout the United States.

In 1941 the author (1) pointed out that more than 2,600 reservoirs had been constructed in this country for public and industrial water supplies. There are now nearly 3,000 such reservoirs supplying some 35,000,000 persons and a large share of the industry of the country. If these reservoirs had to be built at today's prices, they would cost well over a billion dollars. But considering the much greater cost of utilizing less favorable sites for replacement of this storage when it becomes necessary, the existing storage capacity probably has a real worth of several billion dollars.

Seriousness of Problem

As of 1941, surveys of 151 representative water supply reservoirs had shown that one-third of them were losing their storage capacity at a rate of more than 1 per cent annually. Several dozen surveys made since that date have indicated that this estimate is, if anything, conservative, particularly for reservoirs in the states between the Appalachians and the Rockies. In this great breadbasket of America, where row crops predominate, it is to be expected that rates of soil erosion and reservoir sedimentation will be higher than an average which includes many reservoirs in the forested regions of the eastern and western parts of the country.

Studies made since the war have also shown that the accelerated population increase and the generally larger water use per capita, often combined with increased rates of storage loss, will make many reservoirs inadequate sooner than was believed in 1941. Whereas it was then estimated that 21 per cent of all the water supply reservoirs in the country would have a useful life of less than 50 years, additional data indicate that, at least in the midwestern states, more than 33 per cent of the water supply reservoirs will have to be supplemented or replaced before they are 50 years old.

This fact is indeed alarming on several counts. First, many cities have already used the most economical site for a reservoir, and replacements will involve a heavy cost to the water user. Second, in many areas ground water supplies have been developed up to or beyond the limit of safe draft. Both municipalities and industries are being forced to turn more and more to surface water supplies. Third, per capita water use is still generally increasing. Fourth, the population curve, which received a substantial bump during the war period, has not yet leveled out to its 1941 rate. And fifth, rates of erosion and sediment production increased markedly in many parts of the Midwest during the war period as a result of more intensive use of the land for row crops. This condition still prevails four years after the war's end. Had it not been for the effects of soil conservation practices on some of the watershed lands throughout this region, the rates of erosion would have been much higher yet.

Various methods have been used or may be useful in controlling reservoir silting (2). They include such measures as debris basins above the reser-

voir, bypassing sediment-laden flood flows, venting density currents through outlets in the dam, and dredging. All of them have proved feasible under some conditions, but their cost per unit of storage conserved is generally excessive. For most reservoirs, the only practical solution to the sediment problem is the protection of watershed lands and watercourses against excessive erosion and sediment production. This theme was developed in the symposium on watershed protection and maintenance held at the 1946 convention of the Association (3).

Capacity-Watershed Ratio

One factor must always be recognized, however, in evaluating the effectiveness of watershed treatment in protecting any specific reservoir: the rate of silting of a reservoir depends not only on the characteristics of the watershed—such as slopes, soil types, and land use—but also on [1] the ratio of storage capacity to watershed area (or inflow) and [2] the absolute size of the watershed. If one assumes the essential homogeneity of watershed characteristics, then, on an average, [1] the rate of sediment production per unit of watershed area decreases with increasing watershed size in much the same way that the peak rate of runoff per unit of watershed area decreases with increasing size and [2] the annual rate of storage loss decreases with an increasing ratio of storage capacity to watershed area (4).

A comparison of two of the largest reservoirs in Illinois clearly illustrates these relationships. Lake Decatur, on the main stem of the Sangamon River, had an original capacity of 19,738 acre-ft. and a watershed area of 906 square miles, or a capacity-watershed ratio of approximately 22 acre-ft. per square mile of drainage. Lake Springfield, impounded on Sugar Creek and Lick Creek (tributaries entering the Sangamon River below Lake Decatur), had an original capacity of 61,039 acre-ft. and a watershed area of 265 square miles, or a capacity-watershed ratio of 230 acre-ft. per square mile. Recent surveys including estimates of the sediment going past the spillway have shown an annual sediment production rate of 30 acre-ft. per 100 square miles of watershed area above Lake Decatur, and 70 acre-ft. per 100 square miles above Lake Springfield. Watershed conditions, including land use, in the two areas are almost the same. But, despite the fact that the Lake Springfield watershed, though less than one-third the size of the Lake Decatur watershed, produced 2⅓ times as much sediment per unit of drainage area, the rate of silting in Lake Springfield was only 0.3 per cent annually, as compared with a little more than 1 per cent annually in Lake Decatur.

Analyses of data now available from reservoir surveys and suspended-load measurements in central Illinois indicate that in this region a reservoir with 10 square miles of drainage area and a storage capacity of only 500 acre-ft., or 50 acre-ft. per square mile, might be expected to lose its storage at the rate of 4 per cent annually. To have a safe economic life, however, a municipal reservoir should ordinarily have a silting rate no greater than 0.5 per cent a year. In order to provide for this amount on a watershed of 10 square miles, the reservoir should have had a capacity of 3,000 acre-ft. or more. With a watershed of 100 square miles, however, the capacity would need to be only about 10,000 acre-ft., or 3⅓ times as much, to achieve the same safety against premature loss by silting.

These conclusions are necessarily tentative as only meager data are thus far available. Furthermore, the conclusions apply only to Illinois. These studies have shown however, that reservoir sedimentation surveys and analyses of watershed characteristics develop data which are extremely useful in designing new reservoirs. Similar design data should be obtained for every section of the country in which surface water storage and sedimentation are a problem.

The main purpose of this paper is to present the concept of a complete watershed treatment program for reservoir protection in agricultural areas; particularly, the kinds of practices and measures that are generally applicable and needed on reservoir watersheds in the midwestern states, the effects which may be expected from their installation

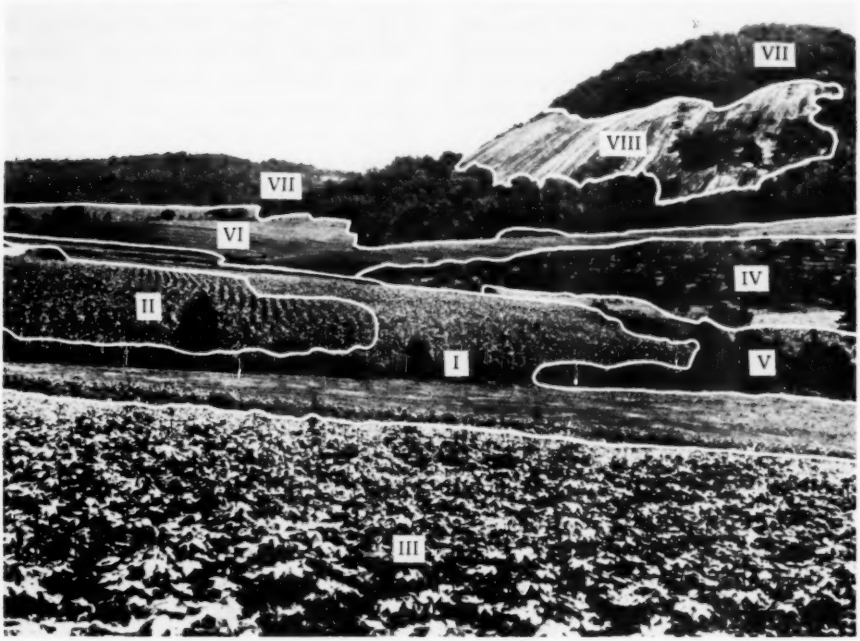

FIG. 1. Land Capability Classes *

* Explanation of classes is given in table below:

Class	Suitable for Cultivation	Class	No Cultivation (Pasture, Hay, Woodland, Wildlife)
I	Requires good soil management practices only	V	No restrictions on use
II	Moderate conservation practices necessary	VI	Moderate restrictions on use
III	Intensive conservation practices necessary	VII	Severe restrictions on use
IV	Perennial vegetation—infrequent cultivation	VIII	Best suited for wildlife and recreation

and, lastly, the status of national, state and local activities that aid in watershed protection. Forested watersheds or land primarily adapted to timber production are not considered here. The value of forests for watershed protection and stabilization of stream flow has been so long recognized that it scarcely needs emphasis. In the midwestern states, however, most of the watershed lands were originally in grass and are now used for grass or cultivated crops. Where there are illustrated in Fig. 1. Several million acres of land in the midwestern states are at present misused with respect to their capabilities. Many more millions of acres are mistreated by poor cropping practices, although they are adapted to their present use.

One measure of misuse is the amount of cultivated land in Classes V, VI, VII and VIII. A preliminary survey by the Soil Conservation Service has shown that the amount of land thus misused runs from a low of 2.3

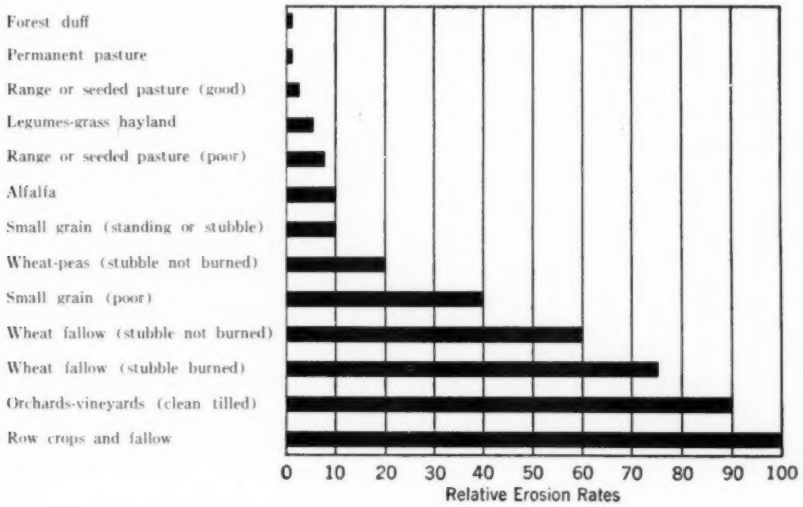

FIG. 2. Relative Erosion Rates Under Different Vegetal Covers

woods, they are considered as farmland tree crops.

Broadly, measures useful for protection of agricultural watersheds may be divided into three categories: [1] land use, [2] cropping practices and [3] channel stabilization and water flow retardation mainly by structural measures.

Land Capability Classes

Land use capability is a concept that has gained wide recognition in recent years (5). Land capability classes are

per cent of the total land use in Minnesota and 2.5 per cent in Michigan, to more than 6 per cent in Iowa, Kansas, Nebraska and Missouri, and a high of more than 8 per cent in Oklahoma. No known practices can maintain the surface soil for long on these classes of land if they are used for row crops. The only way to prevent excessive soil losses is to retire such lands from cultivation to permanent pasture, woodland or other uses in which they will be continuously protected by vegetal cover.

This is not the whole story on land

use, however. The nation's needs and preferences for food and fiber products are not such that every acre of land which might safely produce row crops with adequate conservation practices must be used for this purpose. In fact, millions of acres of land that could produce row crops are even now being maintained in pasture or woods because of economic, social, legal or other considerations. At present, however, the percentage of land in row crops in many parts of the Midwest is as high as it has ever been, and in some places higher. Any means by which the amount of land so used can be reduced will contribute substantially to reduction in the rates of sediment production.

Crop Rotation

Crop rotations are practiced to some extent on most cropland in the Midwest. Millions of acres of land in the Corn Belt of this region, however, have now been in corn continuously for six or seven years, whereas this land would normally have been in corn only two years out of three or three out of four. As a result, the rates of erosion and loss of soil fertility have been greatly accelerated. Other things being equal, the longer the rotation—that is, the fewer years in intertilled row crops during the rotation cycle—the less will be the average soil loss. Figure 2 shows relative rates of erosion under different land uses, with all other factors, such as slope, rainfall, soils and the like, equal for the Pacific Northwest. Relative values are practically the same in the Midwest.

Experiment station data show that a good three- or four-year rotation will give an average soil loss only 14–45 per cent of that caused by continuous one-crop cultivation (6). Erosion losses from a particular field during the year in which it is in grass or other close-growing cover crop may be only 5–10 per cent of the loss during the year it is in corn. Plowing under the grass or cover crop also has a residual effect. The soil loss from corn in the year following grass may be only half as much as in the second year of corn following corn. Thus, long rotations are a form of good land use and are also a good cropping practice.

Other Effective Practices

Cropping practices, however, consist of more than good rotations, use of the right kind of crops on the right kind of land and the application of lime, phosphate or fertilizer as needed. Depending on land slopes, the inherent erodibility of the soil and the intensity-frequency characteristics of precipitation, such other practices as plowing on the contour or planting crops in strips along the contour may be needed to reduce erosion effectively to a rate at which the land is not deteriorating from a higher capability class to a lower one.

Experiment station data have shown that some of these practices are highly effective if applied on land to which they are adapted (7). Twenty-eight experiments in twelve states, carried out during continuous periods of up to eleven years, with a wide range of crops and slopes, have shown that contour cultivation reduces soil loss from sheet erosion by 37.6–100 per cent, or an average of 73.6 per cent, compared with straight-row cultivation.

Similarly, strip cropping, tested in seventeen experiments in seven states with all major crops, slopes and rotations, during periods ranging from one to seven years, showed soil-loss reductions ranging from 10.7 to 94.1 per cent and averaging 69 per cent by comparison with continuous straight-row cultivation of a single crop.

Terracing is a field practice that can be particularly effective in reducing soil losses. Sixteen experiments in seven states on all principal crops and slopes, during periods ranging up to nine years, showed reductions in soil loss ranging from 37 to 98.5 per cent and averaging 85.5 per cent, compared with straight-row, single-crop cultivation.

Other effective field practices that include minor engineering work are farm waterways and farm ponds. Farm waterways are constructed in natural draws, often by sloping and shaping with a grader or bulldozer, followed by seeding or sodding. This procedure not only protects the minor waterways against gully erosion but causes spreading of the surface runoff from the adjacent fields through a vegetated strip, which slows down the velocity and causes deposition of much of the soil washed from the fields. Grassed waterways are effective sediment traps very close to the source of sediment production. Farm ponds, if they are properly designed, are effective traps for most of the sediment produced on the small drainage areas above them. If they are improperly designed with a low capacity-watershed ratio, they may, like larger reservoirs, be silted full before they have justified their cost.

Two recent studies have shown measurable effects from land-use and cropping practices over large watersheds on rates of sedimentation in municipal reservoirs. In one, sedimentation increased; in the other, it decreased, because of what happened on the watershed.

Lake Decatur Study

In 1936 a survey of Lake Decatur, the city water supply reservoir of Decatur, Ill., showed a capacity loss of 1 per cent annually since it was impounded with an original capacity of nearly 20,000 acre-ft. on the Sangamon River 14.2 years previously. A second survey in 1946 showed that the average capacity loss had been 1.2 per cent since the first survey ten years before (8). The rate of silting had increased 20 per cent. A study of inflow to the reservoir from the 906–square mile watershed during the two periods showed that the average annual flow during the first period was 68,000 acre-ft. greater than during the second. Furthermore, during the first period the flow exceeded 1,000 cfs. for 44.6 days per year on an average; whereas during the latter period it exceeded this rate only 36.7 days per year. This comparison indicates that hydrologic conditions were more favorable to erosion and sedimentation during the first period, but the surveys showed that the silting rate was actually 20 per cent greater during the second period.

After considering all of the possible causes for this increase, it could be attributed to only one factor—the increased intensity of land use for row crops. For example, in Piatt County, which is considered typical of the drainage area as a whole, only 39 per cent of the land was used for intertilled crops in 1924. In 1943, 64.4 per cent was in these crops. In the entire Sangamon River watershed, the acreage planted in corn and soybeans increased from 41 per cent in 1922 to 60 in 1945. It is probable that the actual 1946 rate of silting in Lake Decatur for a normal runoff year was 30 per cent above the average level prior to 1936.

If the crop rotation systems recommended by the state experiment station and the Soil Conservation Service were adopted, only 41.6 per cent of the land in Piatt County would be in intertilled crops in any one year, reduc-

ing the intensity of land use to approximately the level of the years 1924–27. This change alone should reduce the capacity loss to about 0.92 per cent annually, or nearly one-third, as field studies have shown that more than 90 per cent of the sediment produced in this watershed comes from sheet erosion on cultivated fields of 2–15 per cent slope.

With the addition of recommended cropping practices, including contour cultivation, grassed waterways, and pasture improvement by liming, fertilizing, seeding, mowing, regulated grazing and farm ponds, it is estimated that the capacity loss would be reduced to about 0.46 per cent annually. This figure is only slightly more than one-third of the probable 1946 rate. It is assumed, of course, that the recommended conservation practices and measures would be applied on all the land in the watershed.

Lake Waco Study

A second study has shown—in contrast with Lake Decatur—a significant reduction in sedimentation as a result of changes in land use and the application of conservation practices (9). Lake Waco, on the Bosque River in Texas, was completed by the city of Waco for municipal water supply in April 1930. This reservoir had an original capacity of nearly 40,000 acre-ft. and a drainage area of 1,666 square miles. During the period of 5.9 years up to February 1936, the average annual rate of capacity loss was 3.35 per cent. During a second period of 11.8 years, from February 1936 to December 1947, the average annual rate of capacity loss was only 2.06 per cent, a reduction of 38.6 per cent from the average for the earlier period.

During the first period the average annual inflow to Lake Waco was 315,000 acre-ft., and during the second it was 435,000 acre-ft. Furthermore, the average number of days per year in which the discharge exceeded all values from 1,000 to 20,000 cfs. was greater during the second period than during the first. In other words, conditions were more favorable to an increase rather than a decrease in the rate of sedimentation during the second period.

The only reasonable explanation for the decreased sedimentation appears to be a change in land use and the application of conservation practices. An analysis of agricultural census data shows that since 1934 approximately 200,000 acres, or nearly 19 per cent of the entire watershed, have been converted from clean-tilled crops, mainly cotton, to pasture. The average size of farms has increased from 198 to 233 acres, and the average income per farm has risen substantially. Tenant farming decreased from 44 per cent in 1930 to 28 in 1945. In addition to this change in land use, conservation measures based on individual farm plans have been installed by landowners and operators on about 10 per cent of the land in the watershed through the soil conservation districts program. Moreover, conservation measures of one type or another have been applied on a considerable additional acreage because of payments to farmers under the Agricultural Conservation Program of the U.S. Dept. of Agriculture and as a result of educational aid by the Federal-State Extension Service, as well as through the natural spread of the conservation idea from farmer to farmer.

"Upstream Engineering"

In many watersheds in the Midwest, however, good land use and good cropping practices are not alone sufficient

to control sediment production adequately. In addition, various types of small engineering works and associated vegetative plantings are necessary to stabilize channels, retard channel flow and impound sediment at widely distributed points throughout the watersheds. Collectively, these measures often have been called "upstream engineering." Where stream channels and minor waterways are actively eroding, they will not necessarily be stabilized maintained unless they are accompanied by proper use and treatment of the land. Thus, land treatment and upstream engineering are inseparably associated in many watersheds. Together they constitute the modern approach to watershed treatment in the interests of runoff and sediment control. A skillfully planned and efficiently executed watershed treatment program bridges the gap between conservation measures for the maintenance of soil re-

FIG. 3. Gully-Head Control Structure

because of reduced fluctuation in rates of runoff and decreased sediment production resulting from improved land use and cropping practices. Indeed, in many areas it is recognized that various channel stabilization, water disposal and sediment control measures must be provided before proper land use and good cropping practices can be obtained on a high percentage of watershed lands. On the other hand, these channel stabilization and water flow retardation measures often cannot be sources on the one hand and major reservoirs, levees and channel improvements to protect main-stem valleys on the other hand.

Figures 3–5 show several types of channel stabilization and flow retardation measures utilized in watershed treatment. These measures include small earth and concrete dams, diversion ditches and dikes, minor floodways, realignment, bank protection and gully stabilization. A gully-head control structure crossed by a

county road is illustrated in Fig. 3. The gully at this point was 40 ft. deep in loess soil, actively cutting headward with vertical sides, which are now slopes and are seeded. There is no detention storage below the spillway sill of the chute, and the total drop is 33 ft. The structure is located in the Nepper subwatershed of the Little Sioux River watershed, 2¼ miles south of Mapleton, Iowa. A gully control drop-inlet dam with an effective height of 18 ft., located in Washington County, Neb., is shown in Fig. 4. The diversion dike in Fig. 5, used to control runoff and carry it to a protected disposal channel, is situated near Winona, Minn.

FIG. 4. Gully Control Drop-Inlet Dam

A question arises about the degree of sediment control which can be expected from this combination of proper land use, good cropping practices and upstream engineering works. Since these measures, in the Midwest at least, require the cooperation of thousands of private landowners, it is obvious that the net result will depend as much, and often a great deal more, on economic and social considerations than it does on physical considerations. Taking into account only the physical factors, it would be possible to reduce the rate of sediment production in many parts of the Midwest by 90 per cent or more. This program would generally entail public acquisition of much of the watershed land and the replanting of a permanent cover of grass or other vegetation. It would require the use of the land in such a way as to maintain this cover, and it would necessitate channel and gully stabilization to whatever extent might be necessary, together with sedimentation basins in some areas.

It is obvious that such complete protection is not generally practicable. In the first place, in most of the Midwest, land values are too high to warrant

public ownership of more than limited areas, such as the immediate environs of a reservoir. Second, from the standpoint of long-range national economy, it is debatable whether the large amount of land now being utilized for reservoir sites, much less the lands of the watershed above these reservoirs, can be permanently removed from agricultural production. Conceding, therefore, that most of the land must remain in private ownership and agricultural use, it follows that landowners on the whole will generally carry out erosion control measures only when they prove to be financially profitable and within the limit of capital expenditure that the landowners are capable of making.

FIG. 5. Diversion Dike

In small subwatersheds (ranging from a few hundred to a few thousand acres) in the Little Sioux River watershed of western Iowa and the Washita River watershed of western Oklahoma, watershed treatment measures already completed or in the process of completion will certainly reduce the sediment output by 75 per cent or more. These measures include dams, gully stabilization, roadside erosion control and flood control waterways, together with such conservation practices on the land as terraces, cover crops and rotations. What has been accomplished in these subwatersheds is capable of being done almost anywhere in the Midwest through subwatershed planning, technical assistance to landowners and public aid in the installation of certain measures.

Soil Conservation Districts

Several forms of assistance are available to both private landowners and municipalities in the protection of watersheds. Most specifically directed toward the control of erosion and the conservation of soil and water are the soil conservation districts, formed under laws which have been enacted in every state and in the territories of Puerto Rico, Hawaii, Alaska and the

Virgin Islands. These laws set up the legal process through which landowners and operators can voluntarily organize and manage districts for the purpose of conservation of soil and water resources. They are entirely controlled by local people.

The twelve-year record of this district movement since the first state law was enacted in 1937 is without precedent in American agriculture. As of January 1, 1949, a total of 2,094 soil conservation districts had been organized. They contain an area of more than 1,100,000,000 acres, or 60 per cent of the total land area of the United States. Actually, however, they include 75 per cent of all the farms and 68 per cent of the land area in farms in the United States, as defined in the 1945 census of agriculture. New districts are currently being organized at a rate of about 175 per year.

The Soil Conservation Service in the U.S. Dept. of Agriculture gives technical assistance in planning, application and maintenance of conservation practices to individual landowners and operators. This assistance is given on recommendations of the supervisors of these soil conservation districts, based on an agreement between the district and the landowner. Soil conservation districts are the principal agency through which municipalities and other reservoir operators can aid landowners and operators in promoting watershed protection. The districts are authorized by law to accept assistance from any source toward the application of soil and water conservation measures within the district. Their elected officials are not only willing but anxious to receive any aid that might be available from reservoir owners. This aid could be in the nature of funds, labor, equipment, materials or educational assistance directed toward expediting and improving erosion control work on reservoir watersheds.

Flood Control Activity

Another form of assistance is available through the flood control activity of the Dept. of Agriculture. Under the Flood Control Act of 1936, the department is authorized to make surveys of watersheds for runoff and water flow retardation and soil erosion prevention. The secretary has delegated this authority to the Soil Conservation Service and the Forest Service. Watershed surveys are made to determine the type of program that should be adopted to secure the maximum benefits in flood and sediment reduction with a favorable ratio of cost and benefits. When reports on these surveys are completed, the secretary of agriculture sends them to Congress. If Congress authorizes a flood control program in the watershed, appropriations are requested to carry out the improvements, based on specific work plans for each subwatershed area. At present such programs have been authorized in only eleven watersheds, on which surveys were completed prior to the war. Many other surveys are in progress, and it is expected that this activity will be authorized in additional watersheds in the near future.

The flood control work is actually carried out on privately owned lands through the soil conservation districts with assistance from the Soil Conservation Service. It consists of an integrated program of measures that includes needed land use readjustments, conservation cropping practices and measures for channel stabilization, flow retardation and sediment control. Most of the flood control funds made available for operations in approved water-

sheds are used for the planning and execution of those measures which are not generally being carried out by the farmers themselves as part of their conservation program developed in cooperation with the soil conservation districts.

"Upstream engineering" measures are needed to bridge the gap between land management and proper conservation farming on the one hand and the large downstream flood control reservoirs and levees on the other. They provide for the orderly disposal of excess runoff and its sediment load through stabilized waterways and stream systems down to the main-stem rivers. Some of these special flood control measures are needed on privately owned lands in almost every watershed. Generally, the landowners cannot afford to undertake this kind of work and often should not be expected to do it because the benefits accrue primarily to downstream farms and urban residents, to reservoir owners and to others who are in the path of floodwaters and floodborne sediment, and not to the landowner himself. On the other hand, when the conservation work, such as land use readjustment and good cropping practices, is primarily of benefit to the individual, he should be expected to carry the major cost.

Several other activities of the Dept. of Agriculture aid in promoting the protection of watershed areas. Among these are payments made to landowners and operators by the Production and Marketing Administration for carrying out approved conservation practices; the Clark-McNary farm forestry assistance through which tree planting stock and expert woodland management advice is made available; the Federal-State Extension Service aid designed to acquaint farmers with better methods of agriculture; soil conservation research; farm credit facilities to make necessary land use readjustments; and others.

Cooperative action of reservoir owners with soil conservation districts, and through them with other conservation activities, could be expected, on the basis of present evidence, to reduce rates of sediment production by 50 per cent or more on most agricultural watersheds in the Middle West within a short span of years.

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Triadelphia Lake Watershed—*Harry B. Shaw*

The Washington Suburban Sanitary Commission is engaging in varied conservation projects on the watershed of Triadelphia Lake, which is the principal source of water supply of the Washington Suburban Sanitary Dist. The purposes of these projects are to conserve water, to reduce the rate of siltation in the lake, to bring about a reduction in the turbidity of the raw water which has to be treated, to develop the watershed so as to provide the maximum recreational use by the public consistent with the requirements for the public water supply, and to produce revenue for the maintenance of the watershed. A description of some of the more important conservation measures being employed may be of interest.

The dam forming the lake was completed in 1943. The original ideas of conservation did not go much beyond the planting of conifers on the nonwooded areas around the lake belonging to the commission. This forestation program was carried on at a moderate rate from 1943 until 1949 and in that time about 350,000 pines of various kinds and 50,000 black locust, tulip poplar and ash have been planted. The one- to four-year-old trees have been secured at a cost of $3.00 to $12.00 per 1,000 from the Maryland State Forestry Dept., but in 1949 the commission was unable to obtain the kind of trees it wanted and decided to forego any forestation of new areas. In 1950, when it is expected the desired trees can be secured, forestation work in the unplanted sections will again be resumed.

Land Use Program

The commission owns 1,738 acres around the lake, which has a full pond water surface of 775 acres. Of the 1,738 acres, 807 are in standing forest. It was originally planned to plant the remaining acreage in trees, as had been the practice in so many places. After the war, however, when it was possible to think in terms of an accelerated development program for the watershed, it was decided to make a study of the commission's holdings to find the best use that could be made of them consistent with the purpose of their purchase. After considerable investigation and study, it was concluded that ground cover other than trees would produce a greater water yield than if trees were planted (1) and would also adequately prevent erosion. The Maryland Soil Conservation Committee and the State Forestry Dept. were then consulted in formulating the basic program which is now being followed on the commission's property.

The study showed that, of the 429 acres not in forest, 235 could be advantageously planted in grass or used for cropping purposes. A serious comparative study was made of the relative revenue-producing merits of a hay and wheat strip-cropping program on the 235 acres and a cattle pasturage program. County agents and practical farmers were consulted. Although the net figures varied somewhat in accordance with individual ideas on yields, operational methods and the like, the conclusion reached was that the programs were financially equivalent. The lesser amount of work and supervision required by the pasturage program plus the subjection of the land to soil erosion by the wheat-hay program—particularly between the time of harvesting and the time of getting the new crop established—threw the balance in favor of the former and it was adopted.

So far, the pasture lands, which are now well established, have been leased to individuals, as the commission has been reluctant to get involved in the cattle market. Commission operation in this field is being explored further, however.

The kinds of trees which will be planted on the remaining 194 acres to be forested have not yet been fully determined. The practicability of developing a Christmas tree crop by a planned thinning out of forest plantings and the economic feasibility of cropping deciduous trees where they could be advantageously planted are being investigated. Suitability of site to growth and the value of the species to water conservation and soil erosion prevention have to be kept always in mind.

The activities mentioned above extend over only the 1,738 acres which the commission owns around the lake, while the watershed totals 50,176 acres. It is apparent, therefore, that an effective conservation program to carry out the purposes set forth in the beginning of the paper depends upon the many landowners on the watershed far more than upon what the commission does on its property. Soil conservation districts have been established in Montgomery and Howard Counties, in both of which the watershed lies, under the State Soil Conservation Committee, but supervised by land occupiers elected from their own number. The commission is a participating landowner.

Erosion Prevention

A survey of the watershed in 1947 showed that one of the principal sources of soil erosion was road banks, shoulders and gutters. The commission in both 1947 and 1948 appropriated $2,000 for soil erosion prevention work by the State Soil Conservation Committee, and this money has been chiefly spent to prevent erosion along roads. The committee is attempting to secure the cooperation of the state and county highway agencies in preventing soil erosion along their highways. Progress is being made now, and the author believes it will continue at an accelerated rate.

It is to the advantage of all landowners, including the commission, to get the soil conservation job on the watershed done as rapidly as possible. The commission therefore increased its 1949 payment to the State Soil Conservation Committee to $5,000. This money will be used for erosion prevention along roads; the purchase of minor equipment used in soil conservation operations which the farmer does not have in connection with his farming operations; and, jointly with money put up by a landowner, for selected soil erosion projects which he would not otherwise be interested in carrying out. All money spent will be on projects which are part of a complete conservation plan, but all negotiations will be between the soil conservation district and the landowner, thus relieving the commission from any liability for claims for damages which might occur. Engineers who are used to seeing large sums of money spent on projects occupying a small area may generally be surprised how far a dollar will go on a soil erosion project. Of course, the contributions of the commission will not directly result in soil conservation of great magnitude. It is felt, however, that it will encourage the landowners and the public highway agencies to engage in soil erosion projects of their own by demonstrating what can be done in this way by expenditures within their means. To augment this program further, the commission has established a one-acre nursery for rais-

ing multiflora rose plants from seed and 24 acres for raising three species of lespedeza seed. Upon approval by the state committee, the plants and seed will be distributed free at the nursery to watershed landowners who will plant them on approved erosion prevention projects on their land.

Public Use

The commission believes that the public, which owns them, should be permitted to enjoy its watershed holdings to the fullest extent consistent with their use as a water supply. The commission allows fishing in the lake both from rowboats and at selected shore locations, but power boats are not permitted. Sanitary facilities are provided at the two boat basins and the approved shore locations. Fishing and boat permits may be secured for a small fee. Boats are privately owned, but they present something of a problem because of the lack of care in maintenance by some owners. Consideration is being given to the elimination of privately owned boats from the lake and the renting of boats by the commission. To insure that the fisherman gets the value of his fishing permit, the commission is cooperating with the Maryland Dept. of Research and Education in a study of the fish resources of the lake. Trap nets have been placed, from which fish are being taken to obtain data on the species, size, weight and age. The trapped fish will be marked and returned to the lake, and fishermen will be asked to report, on a card provided, pertinent data on any such fish caught by them. It is thus hoped to learn much about, and hence improve, the fishing resources of the lake. Fishing permits amounted to $4,064.50 in 1948.

Hunting is not allowed on the commission's property around the lake, and consideration is being given to making it a wildlife sanctuary. Such a procedure would probably provide a greater amount of game on the surrounding properties and still result in a net conservation of wildlife.

Two picnic areas have been established for the use of the public. Sanitary facilities and refuse containers are provided, as well as tables and stone fireplace grills. They are quite popular and have been used in a very orderly manner. A small experimental Christmas tree nursery has been established at one of the picnic areas, which will contain ultimately about 25 species of trees. It is believed that this project will also be of educational value to school children.

The commission's watershed holdings have been entirely fenced, using posts cut on the property. Multiflora rose or other suitable plants will be put in along the fence line. A firebreak extends entirely around the property inside the fence and will be used as a bridle path, as well as to provide access for operation purposes. Other firebreaks have been made as recommended by the State Forestry Dept. through and adjacent to woodlands. Where the firebreaks are in cut or fill, the banks are mulched or planted to prevent erosion.

An ornamental-plant nursery is being started to provide plants for augmenting the natural flowering trees on the commission's holdings. It is hoped eventually, particularly in the vicinity of the dam, to develop a network of paths which will provide pleasant walks for strolling and paths for riding by the public and which will be bordered by flowering plants at most seasons of the year.

Value of Program

This program may appear to some to involve a financial outlay without com-

mensurate return. The commission does not concur in this view. Tentative estimates have been made which show that the soil erosion prevention program is economically sound and the truth of this statement has already been demonstrated for fishing. The extent to which the soil conservation program will conserve water cannot be computed, but whatever the amount conserved, water is worth money—important money—to the public which uses it. Considerable revenue has been obtained from timber and cordwood cut from the firebreaks and in thinning-out operations in existing woodlands. It is believed that timber crops, and possibly Christmas trees, will provide a worth-while, if not large, source of revenue in time. The pasturage of cattle can demonstrably be carried on at a profit. Picnic grounds, bridle paths and scenic walks, although producing little or no tangible revenue, will create goodwill, which is very valuable to a public corporation such as the commission. In short, the commission feels that conservation measures pay.

References

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East Bay District Experience—*J. S. Longwell*

During the past year the Erosion Control Subcommittee of the A.W.W.A. Committee on Watershed Protection and Maintenance has confined its activities to cooperating with the U.S. Soil Conservation Service and arranging to make available to the water supply industry the valuable information collected and prepared by that organization. The operations of the Soil Conservation Service are so extensive and complete that there appeared nothing to be gained by having the Association carry on any independent research or studies.

Some years ago the East Bay Municipal Utility Dist. of California entered into an agreement with the Soil Conservation Service providing for a complete survey by that organization of the watersheds of four reservoirs. These reservoirs furnish terminal storage for the 94-mile aqueduct which brings water from the Mokelumne River, a Sierra Nevada mountain stream, and they also collect runoff from their own watersheds, with a total area of approximately 75 square miles. These four reservoirs have a capacity of 100,000 acre-ft. Although the area of the watersheds is comparatively small, the erosion problem is severe because of the steep slopes and rough topography. The elevations range from 225 at the lowest dam to a maximum of over 1,900 ft. above sea level.

Erosion Control Program

The program outlined by the Soil Conservation Service consisted of: [1] construction of check drops to reduce the grade of the drainage channels; [2] building of silt-catching basins by the construction of earth or masonry dams; [3] tree planting; [4] bank protection; [5] planting of slopes; and [6] range management.

Prior to the war and during the period that WPA help was available, a great deal of work was done throughout the watershed area in following out the recommendations of the Soil Conservation Service. It was necessary, however, to curtail operations during and since the war, and it has only been possible recently to resume operations to a limited extent. Particular attention is now being given to tree plant-

ing, and the present program calls for setting out approximately 100,000 trees each year. It is estimated that since the entire program was started following the survey by the Soil Conservation Service, over 350,000 trees have been planted.

The range management plan, as developed by the Soil Conservation Service, has been particularly helpful. Special efforts have been made to see that all grazing operations are properly controlled and that none of the areas are overgrazed. The district owns and controls approximately 30,000 acres within the watershed area, practically all of which is under lease for cattle grazing. Special five-year leases have been developed during the past few years in which the annual charge is based on the price of cattle and also on the animal months of feed available. These leases have been fully satisfactory to the renters and have resulted in a material improvement in controlled grazing and erosion prevention.

Fire Prevention

From April until October very little rain falls in this watershed area. As a result, the fire hazard during that period is severe. Protection against fires is provided by the operation of two fire observation towers located on high points, together with a number of fire-fighting crews. These crews are equipped with jeeps containing two-way radio sets connected with the system operated by the sheriff of Contra Costa County. The crews are engaged in fence building, watering of new tree plantings, taking care of erosion control structures and other land maintenance activities. In the event of fire, they are notified by radio and proceed to the site of the conflagration. Each jeep is equipped with a water tank and fire pump. Storage tanks are located at strategic points throughout the watershed to provide for refilling the tanks on the jeeps. Adequate fire roads are maintained throughout the watershed area.

With proper control of grazing and adequate fire protection, together with the construction of erosion control facilities, a considerable reduction has already been made in the silt load carried to the reservoirs. It is planned to continue this work in line with the program outlined by the Soil Conservation Service.

The Soil Conservation Service has been most helpful in working with the district toward the solution of its erosion control problems, and it is recommended to water works officials in general that, if they have problems along this line, they contact the Soil Conservation Service and obtain the benefit of its experience.

Control of Bacterial Reproduction in Cation-Exchange Layers

Panel Discussion

A panel discussion presented on May 31, 1949, at the Annual Conference, Chicago.

George H. Klumb

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SEVERAL million service and permanent type cation-exchange water softeners are now in operation in American homes. Countless others are being used for commercial, industrial and municipal water softening. Because water softened by cation-exchange materials provides substantial savings in soap, fabrics and water-heating costs, and improves general cleanliness and sanitation (1), it is exceptionally suitable for domestic use and for many commercial applications.

Gerald C. Baker (2), in 1922, demonstrated the fact that zeolite water softeners filter bacteria from water. He observed that, while a softener might materially reduce the bacterial content of a highly contaminated water, *Escherichia coli* was not quantitatively removed. He also stated that, though a water with an initially low bacteria count may increase in bacterial content upon passage through a zeolite filter, there is no evidence for deciding that such a water is unsuitable for drinking purposes if the raw water is safe. He suggested that a high backwash rate be employed, followed by sterilization with sodium hypochlorite or bleaching powder. W. L. Mallmann (3) recently made a like observation and proposed periodic disinfection.

Bacteria filtered by a water softener may grow in the filter under proper environmental conditions, such as optimum temperature and the presence of filtered organic matter. The contaminating organisms are the usual soil bacteria and may include iron bacteria and sulfate-reducing bacteria. The spore-forming organisms are likely to be present, as the spores withstand municipal purification methods. Although these organisms are not pathogenic, they may be of extreme nuisance value in the formation of objectionable tastes and odors and through fouling of the exchange layer. Coliform bacteria are infrequently found in municipally treated supplies but may occur in private well supplies.

The presence of bacteria and organic matter in potable water supplies demonstrates the need for periodic precautionary sterilization of water softeners, even though inorganic and organic cation-exchange materials have been used without sterilization for many years. Continuous sterilization may be effectively employed in municipal and in large industrial exchangers, but the expense and control involved are not warranted in small industrial, commercial or domestic installations. Periodic sterilization at the time of regeneration has proved extremely effective.

Though the greatest majority of water softeners presently in use are of the

siliceous zeolite type, several excellent new cation-exchange materials have recently been developed for water softening. These materials, in contrast to the inorganic siliceous zeolites, are organic compounds. They may be basically divided into two types—the phenolic type, comprising essentially sulfonated phenol formaldehyde resins, and the nonphenolic type, consisting essentially of sulfonated polystyrene resins. Both the phenolic and nonphenolic resins have several advantages over the siliceous zeolites in that they are somewhat more versatile and have a greater softening capacity. Increased versatility and capacity have resulted in the rapid acceptance and widespread initial use of these resins. It has been found, however, that the new cation-exchange resins cannot be easily sterilized by those methods previously employed for siliceous zeolite.

The purpose of the investigation described in this paper has been twofold. First, it was felt desirable to review the present methods of sterilization of water softeners as practiced in Culligan Soft Water Service plants. Second, it was necessary to find an effective sterilizing agent for the cation-exchange resins.

Sterilization of Siliceous Zeolite

The sterilization of siliceous zeolite water softeners with calcium and sodium hypochlorites has been practiced in Culligan plants since the inception of the service. In the Culligan system, each exhausted softener is brought to a central regeneration plant, where it is backwashed, regenerated, disinfected and rinsed. It is then fitted with sterilized closures and is ready for use.

In order to check the effectiveness of this procedure, a Culligan Service Softener was inoculated with a culture containing more than 350,000,000 *Esch. coli* at the time of capacity exhaustion. A few drops of methyl orange were added to the culture before it was placed in the softener, and water was then added until the effluent showed the characteristic color of the dye. This procedure was followed in order to be sure that the culture had permeated the entire softener layer. The softener was then allowed to stand for several days, at a temperature of 70°–80°F., to secure further bacterial growth. After this period samples of the effluent water and the zeolite mineral were taken. The mineral sample was taken by means of a sterile glass tube, placed in a sterile flask and slurried with sterile water. All tests at this point indicated that contamination was present. The softener was then backwashed in the normal manner at a minimum rate of 10 gpm. per square foot. Samples of the effluent water and the mineral were taken as before, to determine if contamination still existed. All but one test after backwashing indicated that contamination remained.

Calcium hypochlorite was placed on the zeolite layer—using 1.7 g. per cubic foot of zeolite—and the unit was regenerated with saturated sodium chloride brine and rinsed as in normal plant operational procedure. Samples of effluent water and mineral were taken as before and checked for contamination. None of the samples contained coliform organisms after this treatment was applied.

It is generally agreed that the amount of contamination achieved through these inoculations is far greater than that which would be present in any municipal or private well supply, even though the supply were contaminated. The test results bespeak the effectiveness of this method of sterilization of softener units.

In addition to laboratory inoculations, a bacteriological study was conducted in four Culligan plants in the Los Angeles area, under the direction of the late R. F. Goudey. This survey covered monthly examinations in the four plants, having surface and well supplies varying widely in sanitary quality, and included analyses of water taken from units in service at actual home installations. The purpose of the study, which extended from September 15, 1947, to December 15, 1948, was to determine whether water from water softening units serviced, regenerated and sterilized by the standard Culligan method conformed with the drinking water standards of the U.S. Public Health Service. The water from the Culligan Service softeners, as delivered to homes, complied strictly with these standards.

Based on 164 samples, the coliform index was 0.00 per milliliter. The percentage of samples with three or more tubes positive was 0.00, where 5 per cent is allowable. The percentage of standard portions of samples which were positive was 0.37, where 10 per cent is allowable.

Sterilization of Synthetic Organic Cation Exchangers

It has been shown that siliceous zeolites can be easily and effectively freed from filtered bacterial contamination by treatment with hypochlorites during regeneration. This statement is not true for the sulfonated phenol-formaldehyde type of cation-exchange resins. These resins remove chlorine from water and are oxidized by the usual chlorine compounds employed in sterilization. Because of ineffective sterilization and deterioration of the phenolic resin with the usual chlorine compounds, it became necessary to find or develop a new sterilizing agent for these resins.

The need for the new sterilizing agent was brought to the attention of the ion-exchange resin manufacturers by the Culligan Zeolite Co. some years ago. The Rohm & Haas Co. outlined the problem to the Wallace & Tiernan Co., and a cooperative program involving the three organizations was begun over two years ago. The information presented on the sterilization of cation-exchange resins summarizes this long-term cooperative investigation.

The criteria set forth as a basis for the evaluation of a proposed sterilizing agent were: [1] effectiveness and speed of action; [2] absence of deleterious effects on the ion-exchange material; [3] ease and simplicity of application; [4] absence of noxious, toxic or harmful effects; [5] economic considerations; and [6] stability in storage.

The first material proposed for investigation was Hyamine 1622,* a quaternary ammonium compound. Though this material has been very effective as a bactericide, it was found to be unsuitable for the sterilization of cation-exchange resins because it not only reduced the cation-exchange capacity of the resins but also was partially inactivated by the resins because of exchange. The large dosages and long periods of contact which were found necessary for effective sterilization made the material uneconomical and difficult to use (4).

The peroxides were also suggested but were rejected because they caused deterioration of the phenolic cation-exchange resins and because a high concentration and long contact time were necessary for sterilization. The

* A trademarked product of Rohm and Haas, Philadelphia.

handling of concentrated peroxide solutions provides an additional hazard.

Formaldehyde has been used successfully by Cruickshank and Braithwaite (5) for the sterilization of a sulfonated phenol-formaldehyde type of cation-exchange resin. The chief reasons why formaldehyde was not felt to be entirely suitable are the long contact time and the high concentration necessary for sterilization, the relative complexity of the disinfecting procedure, the danger of entry into the water system and the offensive odor.

Another material suggested was chloromelamine, a white, free-flowing powder with a slight chlorinous odor.*

TABLE 1

Sulfonated Phenol-Formaldehyde Resins

Weight of Chloromelamine per cu.ft. of resin g.		Effluent Bacterial Count	
		M.P.N./ 100 ml.	Plate Count
Resin *A*	0	>1,600	63,000
	4.5	0	0
	9.0	0	0
Resin *B*	0	920	1,800
	4.5	0	0
	9.0	0	0

Its sterilizing action is due to the presence of 50 per cent available chlorine. The chlorine in chloromelamine is relatively unreactive to organic matter as compared to hypochlorites, but is still effective against microorganisms. The solubility of chloromelamine in water is about 300 ppm. available chlorine after sufficient contact, which affords a moderate concentration of chlorine for a prolonged period. Chloromelamine is stable in storage and presents no difficulties in handling. Animal toxicity tests performed for fifteen months on rats showed no effect on their growth rate or health. The dosages employed in these tests were many times those which would be consumed by drinking the direct effluent during the sterilization procedure.

Disinfection Experiments

The resins were exhausted by immersing them in a 1 per cent calcium chloride solution for 24 hours. They were then rinsed with distilled water to wash out the excess calcium. The exhausted and washed resins were inoculated with a 24-hour broth culture of *Esch. coli* to give approximately

TABLE 2

Sulfonated Polystyrene Resins

Weight of Chloromelamine per cu.ft. of resin g.		Effluent Bacterial Count	
		M.P.N./ 100 ml.	Plate Count
Resin *C*	0	>1,600	426,000
	4.5	4	0
	5.7	0	0
	6.9	0	0
Resin *D*	0	>1,600	49,000
	4.5	33	200
	5.7	0	0
	6.9	0	0

5,000,000 bacterial cells per gram of resin. Ninety grams of the inoculated resin was placed in each laboratory column for treatment.

The desired weight of chloromelamine was placed on top of the resin. The resin was then regenerated with a proper quantity of saturated sodium chloride brine and rinsed with distilled water at a flow rate equivalent to 1 gpm. per cubic foot of resin. Both the regenerating solution and the rinse water were boiled for ten minutes before use to reduce the possibility of introducing bacterial contamination after the chloromelamine treatment.

* Chloromelamine is otherwise known as: trichloro-2,4,6-triamino-*s*-triazine.

After the rinse an additional 500 ml. of sterile water was run through the column and the last 100-ml. portion of this was collected in a sterile flask containing sodium sulfite (0.1 ml. of 10 per cent solution). This sample was analyzed for total 37°C. bacterial count and presumptive M.P.N. of *Esch. coli*. An additional bacterial count was made on a number of samples of the resin itself. Whenever the rinse effluent was sterile, it was found that the resin was also sterile.

Figures representative of a number of runs have been selected in the compilation of Tables 1–6. Thus, they are not to be regarded as averages or as the results of one single run. The reported dosages represent actual laboratory results but may not be sufficient for the disinfection of cation-exchange materials in actual operation. The proper dosage of chloromelamine can be easily determined from chlorine residuals in the effluent during sterilization.

The method described below for the determination of residual chlorine in chloromelamine solutions is designed for use with chlorine comparators which employ a 15-ml. sample. The method is suitable for other comparators, however, if an appropriate factor is applied.

Add 0.75 ml. of ortho-tolidine reagent, made up in accordance with *Standard Methods* (6), to the comparator tube. Add to this 0.5 ml. of the sample to be tested. After waiting for one minute dilute the sample to the 15-ml. mark on the tube with distilled water and read immediately. Multiply the reading by 30 to obtain the chlorine residual of the original sample.

Tables 1–6 summarize the evaluation of chloromelamine in the sterilization of sulfonated phenol-formaldehyde and sulfonated polystyrene cation-exchange resins. (In all the experiments saturated sodium chloride brine was used for regeneration.)

Although the sulfonated polystyrene resins were as effectively and easily sterilized as the phenolics, slightly more chloromelamine was necessary in each instance, as shown in Tables 1 and 2.

Table 3, which compares chloromelamine and 70 per cent calcium hypochlorite used in disinfecting a sulfonated polystyrene resin ("Resin *C*"), illustrates the ineffectiveness of hypochlorite sterilization under the conditions employed. The results were essentially the same using new resin and resin which had been subjected to treatment with hypochlorite in each of 225 regeneration cycles.

TABLE 3

Comparison of Chloromelamine and Calcium Hypochlorite Effectiveness

Weight per cu.ft. of Resin—g.		Effluent Bacterial Count M.P.N./100 ml.
Chloromelamine	$Ca(OCl)_2$	
0	0	>1,600
4.5	0	2
6.8	0	0
0	4.8	>1,600
0	12.9	920
0	25.8	180
0	51.6	78

It was found that the sulfonated polystyrene type resin does not consume chlorine, except in the first few cycles —an unexpected result, because hypochlorites are known to be effective sterilizing agents. Further work was deemed necessary to substantiate and explain this finding.

The data in Table 4—comparing the consumption of chloromelamine and 70 per cent calcium hypochlorite by a new sulfonated polystyrene type cation-exchange resin and by a resin sterilized in each of 225 regeneration

TABLE 4

Comparative Consumption of Chloromelamine and Calcium Hypochlorite

Per Cent of Total Brine and Rinse	Effluent Residual Chlorine—*ppm.*				
	New Resin		225-Cycle Resin		
	Chloromelamine*	$Ca(OCl)_2$†	Chloromelamine*	$Ca(OCl)_2$†	$Ca(OCl)_2$‡
5	4.3	85	5.3	233	430
10	9.2	48	17.8	118	303
15	13.5	3.2	22.0	8.2	58
20	12.1	1.4	24.9	2.1	19.9
25	22.7	1.1	36.2	trace	8.8
30	21.3	trace	27.7	0	2.1
34.5	16.3	0	19.2		0.7
39.5	12.8		15.6		0
44.5	11.7		11.7		
49.5	8.9		8.2		
54.5	6.8		5.3		
59.5	5.7		4.3		
64.5	3.6		2.8		
69.0	3.2		1.8		
74.0	2.1		1.7		
79.0	1.4		1.1		
84.0	1.4		1.1		

* 6.8 g. per cubic foot of resin.
† 13.1 g. per cubic foot of resin.
‡ 26.2 g. per cubic foot of resin.

cycles—show that the hypochlorite residual, even at high treatment levels, persisted only a short time in comparison to the chloromelamine. The high chlorine residuals shown by the hypochlorites at the beginning of the regeneration period indicate that the hypochlorite was not being consumed, but rather was more rapidly soluble, and, therefore, the residual persisted for a shorter period. In the chloromelamine treatment, the residual chlorine content of the effluent never reached the extremely high values obtained with the hypochlorite but persisted through practically the entire regeneration period.

Some mention has been made of the fact that the disinfection of cation-exchange materials by adding the sterilizing agent to the top of the bed before regeneration might result in recontamination by the brine. This phenomenon cannot occur with chloromelamine, as good residuals persist throughout almost the entire regeneration period.

On reviewing the results shown in Tables 3 and 4, it became apparent that the difficulty which was observed in using the hypochlorite was due to the lack of contact time rather than to ineffectiveness. For this reason, it was felt essential to secure a longer con-

TABLE 5

Addition of Calcium Hypochlorite to Total Rinse Water

Weight of $Ca(OCl)_2$ per cu.ft. of Resin g.	Bacterial Count M.P.N./100 ml.
0	> 1,600
1.6	> 1,600
3.2	79
6.4	2

tact time, which was accomplished by adding 70 per cent calcium hypochlorite to the total rinse water following regeneration with saturated sodium chloride brine. (In the tests, an extra rinse was given to remove residual chlorine.) Table 5 demonstrates that insufficient contact time was the reason effective sterilization was not achieved by placing the hypochlorite powder on top of the bed before regeneration. It proves that effective sterilization can be accomplished, using just slightly more calcium hypochlorite than chloromine in a full-scale water softener using a sulfonated phenol-formaldehyde cation-exchange resin was the same as the method employed with siliceous zeolite, except that chloromelamine was the sterilizing agent rather than calcium hypochlorite. The test results (Table 6) indicate that chloromelamine is as effective in the sterilization of full-scale water softeners as it is in the laboratory.

Although saturated sodium chloride brine was employed for regeneration in the experimental work, in accordromelamine, when the hypochlorite is dissolved in the total rinse water. The method of adding a sterilizing agent to the total rinse water is, however, very unwieldy from a practical standpoint.

Additional work was performed in which the hypochlorite was added to one-quarter of the total rinse water. The results indicated that from four to five times as much hypochlorite per cubic foot of resin was necessary when applied in this manner.

The experimental procedure adopted to test the effectiveness of chloromelaance with the Culligan system, preliminary studies indicate that chloromelamine can be used effectively for sterilizing both sulfonated phenol-formaldehyde and sulfonated polystyrene cation-exchange resins during regeneration when a 10 per cent sodium chloride brine is used as the regenerant. Further experimental evidence also indicates that the cation-exchange resins are more easily sterilized during regeneration or in the regenerated (sodium) state than in the exhausted (calcium) state. Preliminary studies show

TABLE 6

Full-Scale Water Softener Sterilization With Chloromelamine (Sulfonated Phenol-Formaldehyde Resin)

Weight of Chloromelamine per cu.ft. of Resin g.	*Esch. coli* Test Results*					
	Before Backwash		After Backwash		After Regeneration, Sterilization and Rinse	
	Effluent	Resin	Effluent	Resin	Effluent	Resin
5.3	+	+	+	+	−	−
4.8	+	+	+	+	−	±
4.8	+	+	+	+	−	−
4.5	+	+	+	+	−	−
4.5	+	+	+	+	−	−
4.5	+	+	+	+	−	−

* Meaning of symbols:
+ confirmed positive
− negative presumptive
± presumptive but not confirmed

that chloromelamine can also be used effectively to sterilize cation-exchange resins operating on the hydrogen cycle, as well as anion-exchange resins.

Effect on Exchange Capacity

Several sulfonated phenol-formaldehyde and sulfonated polystyrene cation-exchange resins were automatically recycled in laboratory columns. Chloromelamine was applied with each regeneration through 450 cycles on one set of columns. A duplicate set of columns was recycled simultaneously, without sterilization, as a control. The amount of chloromelamine employed in each cycle was approximately 12 g. per cubic foot, or about twice that necessary for sterilization. Determinations on the treated and control columns after 450 cycles indicated that the chloromelamine had no deleterious effect on capacity.

Summary and Conclusions

Both siliceous and resinous exchangers may become contaminated with bacteria filtered from the water supply. Although experimental evidence indicates that the siliceous and resinous exchangers are incapable, in themselves, of sustaining bacterial growth, bacteria may grow in the softener material because of the presence of filtered organic matter, especially during optimum temperature conditions. These bacteria are chiefly soil organisms which may be of extreme nuisance value through fouling of the exchanger and the formation of objectionable tastes and odors. Coliform organisms are infrequently found in municipal supplies but may occur in private well supplies. It has been found that such contamination of exchangers can be effectively controlled by sterilizing the softening unit at the time of regeneration, after backwashing. Siliceous cation exchangers can be effectively disinfected during regeneration by the application of calcium or sodium hypochlorite.

Since the sulfonated phenol-formaldehyde cation-exchange resins removed chlorine, and were oxidized by the usual chlorine compounds, it was necessary to find a compound which would effectively disinfect these resins without injury to the resin. Although it was assumed that the hypochlorites could be used to disinfect the sulfonated polystyrene cation-exchange resins, experimental work proved that sterilization during regeneration would be difficult.

A new sterilizing agent, chloromelamine, has been found to be very effective, economical and simple to apply in disinfecting both the sulfonated phenolformaldehyde and sulfonated polystyrene cation-exchange resins, as well as the siliceous exchangers, during the regeneration period, without deleterious effect on the exchanger.

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To begin with, the author would like to comment on the manner in which microorganisms accumulate on the exchange material. George H. Klumb has pointed out that the consensus favors a filtering action. In addition, the high-capacity organic exchangers may hold some organisms by true adsorption. Any growth that takes place has been attributed to the accumulation of organic debris, which serves as a supporting medium. Some experiments carried out in the Wallace & Tiernan laboratory confirm this belief. To test the effectiveness of various procedures for sterilizing exchange materials, it was desirable to have a standard way of contaminating them. It was soon discovered that the inoculation of a clean resin layer with a washed suspension of organisms was not sufficient to start bacterial growth. To obtain growth on or in the resin particles, it was found necessary to add small amounts of peptone or broth.

Eventually it proved unnecessary to have the organisms actually growing on or in the particles. Comparative experiments showed that the required treatment was the same whether the organisms had grown within the layer from an inoculum or whether the same final number of organisms was merely mixed into the resin material.

Chloromelamine Characteristics

It may also be of interest to discuss some characteristics of the chloromelamine preparation itself. Its germicidal activity is due to the presence of available chlorine, which is bonded to nitrogen. As in all chloramines, there are two oxidizing equivalents per atom of chlorine. In this form, available chlorine is markedly less reactive chemically than in hypochlorites. Chloromelamine is one of the slowest in releasing hypochlorous acid. The resulting low reactivity with extraneous organic matter is the reason why chloromelamine does not attack exchangers which are very readily attacked by other forms of active chlorine. It also makes it possible to carry high chlorine concentrations through the exchanger layer even though a great deal of organic contamination is present. Finally, the contaminating material, which greatly decreases the germicidal activity of chlorine or hypochlorite, has practically no effect on chloromelamine.

The importance of the solubility characteristics of the preparation is evident from Klumb's data. The solubility is great enough and the material goes into solution fast enough to give a chlorine concentration of the necessary magnitude. On the other hand, the solubility is not so great that the powder is all dissolved away by the first part of the brine, which would give a high initial concentration for a short time. As Klumb has pointed out, a reasonable concentration over most of the period of the regeneration and rinse is much more effective than a very high concentration for a short period.

An additional advantage of the persistence of the material in the exchanger layer is the fact that any contamination introduced by the brine can be counteracted. The chloromelamine residual is present in the rinse long after all of the brine has been introduced. Sodium chloride solutions are as easy to sterilize as plain water with available chlorine in this form.

It is occasionally not feasible to introduce the powder on the top of the

layer directly. The procedure then is to make a concentrated suspension which can be pumped into the top of the unit in any way desired. The solubility is such that it is not possible to prepare a clear solution of sufficient concentration for this purpose, but the material wets readily and easily forms a suspension, which requires only slight agitation to prevent settling.

Another characteristic of this preparation, which is frequently of importance from a practical point of view, is the fact that it does not raise the pH of the solution in which it is dissolved. Actually, there is a slight lowering.

Effect of Sodium Chloride

Klumb experimented with saturated sodium chloride because it is commonly used in the regeneration process as practiced by his organization. In the Wallace & Tiernan laboratory, other sodium chloride concentrations have been tried to ascertain the relative ease of sterilization with chloromelamine. It was found that the sodium chloride increases the effectiveness of the sterilizing agent, as compared with its action in plain water. With some exchange materials, the higher the concentration of sodium chloride, the less sterilizing agent or the less contact time is necessary. Thus, using a 10 per cent sodium chloride brine, such products would require larger quantities of chloromelamine than if a saturated sodium chloride brine were used. This point is important to remember when a different brining method is used, as in some industrial plants.

The fundamental reason for the effect of sodium chloride on sterilization is not definitely established. There is some evidence that the properties of the exchange resin itself are involved. The effect of sodium chloride varies for different exchange materials. It is also known that calcium ion in the exchange resin seems to protect the organisms, as, indeed, calcium ion is known to protect against other disinfecting agents. It has been found much harder to sterilize all exchange materials in the exhausted state by dissolving the chlorine compound in plain water. Perhaps it is important to get the calcium ion content down to a certain level quickly, in order to give ample contact time between the chlorine compound and the resin after the protective effect of the calcium has become negligible. Conceivably, different samples of exchange material will differ in their rate of exchange and in the extent to which it varies with the salt concentration. If this is true, it might be expected that different exchangers would react differently to varying salt concentrations.

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Base-exchange softeners and sand filters afford environments which are ideally suited to the development of many kinds of bacteria, and unless steps are taken to prevent it, they will always support luxuriant growths of all bacteria gaining access to them which find those surroundings favorable. Such bacterial populations consist almost entirely of soil and water forms, and all of them are sedentary in habit, attaching themselves to the surface of the granular material and to walls and pipes. As a result, they cannot be effectively removed by backwashing, while the fact that they bury themselves in a coating of slime (pectin), which often completely envelops one or many grains of sand or exchange material, interferes with the action of bactericides.

In the popular mind, the mention of bacteria conjures up fear of disease; hence it is not surprising that the public health significance of growths in structures treating water for human consumption has been brought forward. In practice, whether a large municipal installation or a small unit in a private home is involved, the water applied to an exchange softener has generally been specially processed for human consumption and is free from pathogenic organisms. Consequently, there would seem little opportunity for pathogens to enter.

Slow sand filters, which depend upon prodigious growths of microorganisms for the natural purification of polluted waters, have been in use for many years, but they have never been regarded as public health hazards. Quite the contrary, in 1892 such filters protected residents of Altona, Germany, against cholera which raged in the adjoining city of Hamburg. Both cities were taking cholera-infested water from the river Elbe, but Hamburg had no filters. In this instance, a heavy growth of the same kinds of bacteria that flourish in softeners not only did not jeopardize the public health, but actually proved to be its protecting bulwark.

At present a controversy is raging between two schools of bacteriologists over the role played by the *Proteus* bacillus in food poisoning. One group maintains that it fabricates a toxin which when ingested causes the symptoms of the disease, while the other group denies its culpability. This organism is one which is abundant in soils and could find its way into softeners, although its ability to flourish there may be questioned.

After having discussed the matter with a number of prominent bacteriologists and public health officials, the author feels confident in stating that the profession in general regards the menace to public health of growths in softeners and filters as nonexistent.

Growths may and often do contribute objectionable odors and tastes to the treated water, and they may cause deterioration of the exchange materials. Siliceous exchangers may lose silica under bacterial attack. Waksman (1) states:

> The bacteria were able, by means of their products of respiration, to dissolve considerable amounts of pulverized silicates; the formation of organic acids by *Bac. amylobacter* markedly influenced the solubility of silicates. The intensity of contact of the organism with the mineral to be acted upon was found to be of even greater importance than the other agents of solubility. Thus, *B. extorquens*, which produced only carbon dioxide, but which formed a close and firm envelope around the mineral particles, had the strongest solvent action.

The Metropolitan Water Dist. of Southern California has experienced severe loss of silica from siliceous zeolites and has had to add sodium silicate to the water to correct the evil, at considerable expense. It is possible that bacteria may have played a part in this loss, but no study was made at that time of growths in the zeolite units.

The phenolic and polystyrene resins, which are now so widely used, are organic compounds, and it seems quite true that there are no known organic substances, natural or synthetic, which are not utilized by some bacteria under some conditions. We should not expect, until it has been proved to us to the contrary, that synthetic resins imbedded in a mass of living bacteria will be immune to biological attack. Our study shows that bacterial populations as high as 6–10 million viable cells per milliliter of exchange resin (it is

difficult and unnecessary to reduce these figures to a gravimetric base) exist in cation exchangers operated without germicides.

Experimental Softeners

The Metropolitan Water Dist. of Southern California has kept ten experimental softeners in continuous service for approximately two years, during which time the water applied to them has been filtered, carbonated and chlorinated. Each unit is charged with a different type of exchange material but otherwise they are all alike, and all have been operated in the same manner. Chlorine in the applied water has varied from 0.5 to 0.05 ppm., with the average at 0.2 ppm. Bacterial counts were made at approximately weekly intervals from January 7 to May 11, 1949, on influent and effluent waters. The influent counts on standard agar incubated 168 hours at room temperature ranged from a minimum of 15 up to 900 colonies per milliliter, with an average of 200. Counts on the softened effluents after incubation for 168 hours at room temperature varied as shown in Table 7.

TABLE 7

Effluent Bacterial Count

No. of Units	Softener Material	Colonies per ml.		
		Min.	Max.	Avg.
2	Siliceous	13	1,800	210
		61	2,000	460
1	Carbonaceous	100	18,000	2,800
4	Phenolic	53	2,300	800
		28	5,900	620
		19	1,800	470
		50	5,900	860
3	Polystyrene	15	450	110
		19	900	180
		22	12,000	900

All three polystyrene units carried residual chlorine in the effluents throughout the run, ranging from 0.05 to 0.5 ppm. The phenolic units generally had no residual in the effluents while 0.05 was reached in only five samples out of 58, and 0.1 was reached only once. The effluent from the carbonaceous unit carried a residual of 0.05 ppm. in one sample out of fifteen, the other fourteen showing zero readings. This material, which has a carbon base and which may be operated on either the sodium or hydrogen cycle, absorbs chlorine, permitting growths on the sodium cycle although none occur when operating on the hydrogen cycle. The effluent of the two units charged with siliceous material carried chlorine residuals ranging from 0.05 to 0.40 ppm., with the average a scant 0.20.

These results prove again that phenolic resins and carbonaceous exchangers combine with chlorine, removing it from the water, so that chlorine cannot be satisfactorily used to prevent bacterial growths in such materials.

It was believed that the influent and effluent counts were inadequate to disclose the extent of growths in the exchange material, for such growths are

adherent to the granular material and are not readily dislodged. To check the validity of this belief, samples of the exchange material were taken from nine of the above units and subjected to bacteriological examination. One-milliliter portions were taken aseptically from the surface inch and at points 5 and 10 in. below the surface. These were added to Erlenmeyer flasks containing 50 ml. of tap water and a quantity of broken glass which had been sterilized in the autoclave at 15-psi. pressure for fifteen minutes. After thorough shaking to remove bacteria from the granular material, aliquots of these dilutions varying from 0.02 to 1 ml. were plated on standard agar and incubated at room temperature in the dark for 72 hours. Examination of the plates gave the following results: One polystyrene exchanger failed to produce colonies at all levels and another gave zero counts in the surface inch and at a depth of 10 in., but developed 1,000 colonies per milliliter at a depth of 5 in. These units were sampled in this way on only one day, so such anomalies had no chance to be compensated for. The evidence is, of course, that the overall growth was slight, at least to a depth of 10 in.

A third styrene base material gave no colonies at the surface or at 5 in., but produced a count of 1,000 per milliliter at a depth of 10 in. These findings would seem to imply that chlorine residuals ranging from 0.05 to 0.5 ppm. and averaging 0.2 ppm. were insufficient to carry protection throughout the unit.

One sample of siliceous material yielded 1,000 colonies per milliliter in the surface inch, none at 5 in. and 2,000 at 10 in. Another siliceous material produced no colonies in the surface inch and 1,000 per milliliter at both 5 and 10 in. It would appear that the chlorine dosage here had not been sufficient to carry residuals below the superficial layer.

One carbon base exchanger which is known to absorb chlorine produced 48,000 colonies per milliliter in the top inch, 120,000 colonies at a depth of 5 in. and 390,000 at a depth of 10 in. Although this unit had continuously received water carrying chlorine, its effluent showed a chlorine residual as high as 0.05 ppm. on only one occasion. Obviously, the growths here could not be completely controlled by chlorine, yet after two years they were not comparable with those found in phenolic material similarly treated over the same period.

No data have been obtained to show to what degree chlorine may have deleteriously affected the exchanger.

Three phenolic resin exchangers gave the following growths:

Colonies per Milliliter

Surface Inch	5-in. Depth	10-in. Depth
4,875,000	4,550,000	3,550,000
2,600,000	2,250,000	5,700,000
650,000	160,000	150,000

The last unit carried no higher residuals in its effluent than were found in the other phenolic resins, and no explanation of the lower bacterial growth found is offered other than to suggest the possibility that a different molecular structure might have been responsible. The same material was used in two other experimental units set up to test the efficiency of formaldehyde as a bactericidal agent. In the unit employed as a control—where the raw water was treated without formaldehyde—this phenolic resin material showed the highest growths found in all the work, but in the unit treated intermittently with formaldehyde just preceding regeneration, the growths

produced were lower than those reported above for the chlorinated unit which had been in use for two years.

Additional Experimental Units

To illustrate further the need for bacterial counts on the exchange material, six additional experimental units were set up in three pairs. Two units were charged with siliceous material, one receiving raw water and the other chlorinated raw water. Two were filled with phenolic resin, one being treated with formaldehyde before each regeneration, which occurred twice a week, while the control unit was not so treated. The remaining two units were charged with polystyrene resin, and one received raw water while the other had chlorinated raw water. All the units were operated in the same manner and samples were taken twice each week for three weeks.

In this series of experiments the same procedure was employed as has just been described for the examination of the solid exchange material. The raw water used was unfiltered and had a relatively high content of organic matter. The figures obtained were consistent in showing that the use of bactericidal agents strongly restrained growth in nonphenolic material and that all three types of exchange material used without such agents supported heavy bacterial populations which increased markedly with the passage of time. The heaviest populations were found in the phenolic resin, where the maximum was 15,000,000 cells per milliliter in the surface inch and the minimum was 975,000. At a depth of 10 in., the minimum count was 182,000 and the maximum, 4,400,000.

Polystyrene without chlorine showed a maximum in the top inch of 6,175,000 cells and a minimum of 465,000. At a depth of 10 in., the figures were 4,875,000 and 175,500, respectively. Siliceous material gave a maximum of 6,600,000 and a minimum of 370,000 in the top inch, when the unit was operated without chlorine. At a depth of 10 in., the figures were 4,450,000 and 130,000, respectively.

The results on the samples of siliceous material in the unit operated with chlorine were inconsistent because of fluctuations in the chlorine dosage. One day the chlorine dosage reached 5 ppm. and the samples at all depths failed to develop colonies. The highest count obtained on this material during the tests was only 90,000 cells at a depth of 5 in. The highest count in the top inch was 58,500 and the lowest, zero. Only the last day's samples showed the expected distribution of bacteria—that is, none in the surface inch, 50 cells at a depth of 5 in. and 100 at a depth of 10 in. below the surface.

Polystyrene resin operated with chlorine showed great reduction over the findings on the same material without chlorine, but again the chlorine dosage fluctuated within wide limits. Contrary to expectations, in all the samples from this unit, the highest counts were in the top inch, varying from 50 to 1,750,000 cells when the chlorine dosage failed. The lowest counts in all the samples from this unit were found at a depth of 10 in., where the maximum was only 9,000 cells per milliliter and the lowest was zero when the chlorine dosage was highest.

The phenolic resin treated with formaldehyde just before regeneration gave a maximum count of 268,000 in the top inch, as compared to 15,000,000 in the same material not treated with formaldehyde—a reduction of nearly 98 per cent.

Intermittent sterilization is employed in all bacteriological laboratories, but it is always repeated at 24-hour intervals. Under these conditions, it produces satisfactory results, although even after three daily sterilizations a small number of tubes will still exhibit growth. From the results obtained in this series of experiments it seems reasonable to believe that the formaldehyde treatment of phenolic resins at 24-hour intervals, which might be done in a municipal installation, would prevent troublesome growths. Such treatment might be found impracticable in actual service. In small home installations, where the use of bactericides would occur only at weekly or monthly intervals, its value would seem doubtful.

Conclusions

The conclusions to be drawn from the present work are:

1. Unless controlled, heavy bacterial growths will develop in all cation-exchange softeners.

2. Bacterial counts in influent and effluent samples, although indicating growths, fail to give an idea of the extent of their development in the exchange medium.

3. The effective control of growths in siliceous and polystyrene materials can be obtained through continuous adequate chlorination. Phenolic resins and carbon base materials operated on the sodium cycle should not be treated with chlorine, but growths in them can be controlled by intermittent treatment with such a bactericide as formaldehyde, although that treatment might be found impracticable under service conditions.

4. The consensus of bacteriologists and public health officials contacted is that the public health menace caused by bacterial growths in sand filters and exchange softeners is very slight and probably nonexistent.

It is the firm belief of the author that excessive growths of microorganisms in any and all structures in the treatment plant and in the distribution system should be prevented. Such growths always impair the flavor of the water and are active agents in corrosion, giving rise to consumer dissatisfaction and complaint and providing the urge to greater use of bottled waters. Off-flavored water will always lead critical consumers to suspect it of being the causative medium in cases of ill defined allergies and digestive disturbances, and honest but poorly informed physicians who will support such suspicions can always be found.

Further work on the control of growths in exchange softeners and sand filters is indicated, and sampling should extend throughout the depth of the units, including the supporting gravels, if possible.

Acknowledgment

The work here reported could not have been done but for the courtesy of William W. Aultman in placing the almost unlimited facilities of the La-Verne laboratories of the Metropolitan Water Dist. at the author's disposal and in detailing various members of his staff to assist in setting up and operating all the equipment involved. The author also wishes to thank Hollis Page, of the district staff, and Lillian Zupnick, of his own staff, for carrying out the tedious work of the bacteriological examinations.

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Effect of Age and Storage Temperature on Bacteriological Water Samples

By K. E. Cox and Frost B. Claiborne

A paper presented on Sept. 30, 1948, at the West Virginia Section Meeting, Clarksburg, W.Va., by K. E. Cox, Director, and Frost B. Claiborne, Supervisor of Sanitation Bacteriology both of West Virginia State Hygienic Laboratory, Charleston, W.Va.

SINCE 1928 all editions of *Standard Methods* (1) have specified that: "Because of the rapid and extensive changes which may take place in the bacterial flora of bottled samples when stored even at temperatures as low as 10°C., it is urged that all samples be examined as promptly as possible after collection. The time allowed for storage or transportation between the filling of the sample bottle and the beginning of the analysis should not be more than six hours for impure waters and not more than twelve hours for relatively pure waters. During . . . storage, the temperature shall be kept between 6°C. and 10°C. Any deviation . . . shall be stated."

Published Data

There is relatively little in the literature to indicate the effect of time and temperature on coliform population in water samples, and even what exists is somewhat contradictory and confusing. A survey (2) of actual practice in the United States in 1933 showed that the refrigeration of water samples during transportation was a rapidly disappearing practice and that a large number of samples were not examined within 24 or even 48 hours. Berry (3) said in 1926 that "the number of colon group bacteria in samples of ground water did not change materially in the first 48 hours after collection, regardless of whether samples were kept at ordinary temperatures or packed in ice. Samples shipped without ice packing will, therefore, yield dependable results." Caldwell and Parr (2) in 1933 examined a large series of water samples from "good," moderate and bad (sewage-contaminated) supplies immediately after collection; and also after being held for 24–30 hours, iced and un-iced. They concluded that "though the difference in recovery of coli-aerogenes organisms . . . from iced and un-iced samples held for 24 or more hours is slight, possibly because of the susceptibility of certain [*Aerobacter*] *aerogenes* to cold, the yield of [*Escherichia*] *coli* in favor of the iced probably is significant." (Iced samples yielded about one-half and un-iced samples, less than one-fourth, of the original coliform count.) In 1941 Borman *et al.* (4) stated that "there is presumptive evidence but no proof that coliforms introduced into a [municipal water] system may multiply, probably to only a limited extent, under warm weather conditions in small pipes at points when volume of flow is low and residual chlorine negligible."

Gainey (5) points out that there is no way of predicting the effect of storage upon bacterial change in stored samples. This statement probably re-

fers chiefly to total bacterial population rather than coliform population. Although it is generally agreed that plate counts of total bacterial population often increase at room temperature or above when examination is delayed, Gainey cites data from the U.S. Public Health Service showing that, when a sample with an initially high count was held at 10°C., the total population remained approximately the same for 24, 48 and 72 hours after collection. The same sample held at 20°C. showed approximately the same total count for 24 hours; then the organisms died out very rapidly. Increasing the storage temperature to 30°C. speeded up the population decrease materially. Gainey also regards the results of Caldwell and Parr (2), on the recovery of *Esch. coli* from iced and un-iced samples held for four to seven hours, as an indication that the coliform population changes rapidly. Cox (6) cites no data not already mentioned but says that "Many bacteria multiply in samples of water kept at room temperature, but this does not occur . . . below 45°–50°F. Organisms of the coliform group do not multiply in water . . .; they gradually die in water at room temperature. Thus, there is no increase in density of these bacteria when examination of a sample is delayed." Therefore, he says, samples should be examined immediately or should be refrigerated until examined.

In 1946 Griffith (7) sent questionnaires to public health laboratories in the United States and received replies from 28 states. Only four indicated that refrigeration of samples was used at all. Twenty-six reported shipment by parcel post, unrefrigerated, as the usual method. Fourteen laboratories examined specimens within 24 hours; and eighteen, within 48 hours after collection.

Need for Practicable Standards

This brief review of the literature reveals that sparse experimental data accumulated years ago have apparently set the pattern for requirements on age and storage temperature of bacteriological samples of water. Little seems to have been done of recent years in the United States to find age and temperature limits which will give reasonably dependable results and which are sufficiently practicable so that they will actually be used. There seems slight value in having standards which have been unchanged for at least 25 years, and which almost no one follows.

TABLE 1

Coliform Index of Water Samples

Source of Sample	No. of Samples	Coliform Index (M.P.N.)		
		2.2 or Less	More Than 2.2	More Than 16.0
		Samples—*per cent*		
Public supplies	1,928	84	16	9.4
Semipublic supplies	899	60	40	26.0
Swimming pools	744	84	16	12.5

In West Virginia, the State Hygienic Laboratory Div., like most state public health laboratories, has accepted water samples of varying ages, unrefrigerated. During the hottest weather in the four months from May 17 to September 11, 1948, 84 per cent of 1,928 samples from known public drinking water supplies (large municipalities, mining and lumber camps, and so forth) showed coliform recoveries (M.P.N.) of 2.2 or less per 100 ml. of sample (*see* Table 1). This finding suggests that, in all probability, these public supplies were meeting the bacteriological requirements for the safety of drinking water used in interstate commerce. But,

since some of these samples were 48 hours old or more, and not refrigerated, it is possible that, though they seemed "good" when examined, they were actually worse when collected. Conversely, it seems possible that the 9.4 per cent of public supply samples which showed a coliform M.P.N. greater than 16 when examined (indicating drinking water of very poor quality) might have been either better or worse when collected. This uncertainty appears needless; there should be more assurance about the quality of a product which so definitely affects

TABLE 2

Coliform Population Variation With Age

Extent of Pollution	Age of Sample—*hr.*			
	0	12	24	48
	Coliform Population—M.P.N.			
Low	390	390	390	160
Medium	8,800	16,000	15,000	15,000
High	50,000	24,000	25,000	11,000
High	24,000	24,000	25,000	24,000
High	44,000*	45,000*	10,000*	11,000*

* Sample kept at room temperature (approximately 29°C.). All other samples refrigerated.

the health of so many people. For a majority of these supplies, the Hygienic Laboratory Div. results afford the only regular bacteriological control. True, the typhoid fever rate has steadily decreased, but too many cases still occur every year. Gastroenteritis affects large numbers of children and adults every summer, and water supplies in various states have been repeatedly incriminated (circumstantially) as the probable source.

Representative Samples

The State Hygienic Laboratory runs all bacteriological examinations for the West Virginia Water Commission's stream pollution studies. The commission states that the coliform index provides a better means for determining the presence of domestic (as contrasted with industrial) sewage than any of the various chemical and biochemical tests. But in previous years coliform indexes on a given stream showed fluctuations to an undesirable degree, when based on examination of "grab" samples, unrefrigerated and of varying age up to 48 hours. Therefore, the first necessity was to determine "sampling error," or variation of

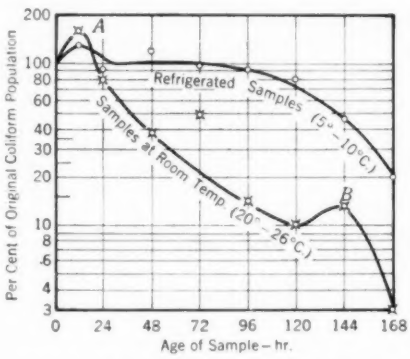

FIG. 1. Coliform Population Changes
A—Primary rise (0–24 hours)
B—Secondary rise (about 3–6 days)

coliform population in multiple "grab" samples collected simultaneously at the same spot and examined immediately, using five portions in each of three or more serial dilutions of sample. Repeatedly, when four bacteriological sample bottles were strapped to the outside of a dissolved-oxygen sampler to collect simultaneous samples from the Kanawha River, individual samples varied from "less than 6,700" coliforms up to 70,000–90,000, or more than tenfold. When multiple samples were poured in quick succession after thorough shaking of the water in the sampler, the greatest variation between individual samples was less than fourfold, and mostly about

twofold, which is within the limits of accuracy of M.P.N. determinations. The latter method of collection was used in all the experiments described herein. It has since been adopted by the water commission, which collected about half of the samples observed for effect of age and temperature. Results of hourly and "composites" of hourly samples taken throughout the summer of 1948 at the same site have been remarkably constant, another indication that this technique obtains representative samples.

Age and Temperature Effect

Multiple samples from streams showing high, medium and low pollution were examined in the summer of 1947 and 1948, with strict adherence to all details of technique required by *Standard Methods*. Each series of samples was examined: [1] immediately after collection—mostly within one hour, always within 2½ hours; [2] thereafter, at 12-, 24- and 48-hour intervals, and sometimes daily up to seven days, stored refrigerated (6°–10°C.) and at room temperature (approximately 26° C.).

Figure 1 represents schematically a composite of results obtained on river water highly polluted with sewage. The range of coliform organisms in these samples was 5,400–17,000 (M.P.N.) at zero hours. Table 2 shows the results for some raw waters with varying degrees of pollution.

All examinations from each source were repeated at least twice, with similar results. Refrigerated samples from all sources tested, including rivers and a private swimming pool, showed relatively unchanged coliform population (within twofold variation of M.P.N.) for samples 0–48 hours old, and sometimes after 96 or more hours. Samples stored at room temperature (about 26°C.) showed erratic and unpredictable fluctuations of coliform population. Sometimes the coliforms were increased slightly in the 24-hour samples, but usually they dropped sharply within 24 hours and almost always by 48 hours, reaching a level only about one-half to one-fourth of the original population. By 72 hours, unrefrigerated stream samples usually showed about 5 per cent of the original coliform population. On the other hand, the private swimming pool experiment (the pool was filled with chlorinated city water but was not chlorinated during use) showed that the coliform population increased when samples were stored at room temperature, and this increase was even more rapid in samples stored in a bacteriological incubator at 35°C. (96°F.). The final population after 72 hours at room and incubator temperatures was about five- to tenfold greater than in the refrigerated samples, which remained constant for 72 hours after collection. It is evident that coliform organisms can multiply in old water samples in warm weather, though in general they probably decrease.

These studies are really pitifully meager, but they are more than the authors have been able to find in the literature, and it is hoped that they will serve to point up a great need for further investigation in this field.

The results of the studies indicate reasonable and practicable means for adhering to age and temperature limits which can and should be observed for water specimens to be examined for coliform organisms. Practicable standards for storage and transportation should make the coliform test even more valuable; it is now universally recognized as the most dependable bacteriological or chemical test to determine the safety of drinking water, in

either treated waters or untreated surface waters.

As a consequence of these studies, the West Virginia State Hygienic Laboratory rejects all unrefrigerated water specimens submitted for coliform examination if they are over 48 hours old. If possible, this age limit should be reduced to 24 hours.

It is urged that stream pollution samples be refrigerated during transportation and that collection and transportation schedules be so coordinated that these samples reach the laboratory within 24 hours or less after collection. Since July 1948 the West Virginia Water Commission has used a light-weight, inexpensive, insulated shipping case which holds about eighteen or twenty sample bottles, and which has maintained bacteriological samples between 3° and 10°C. for about fourteen hours. This case is simply a corrugated cardboard box, 11 × 8 × 8 in., completely lined with light-weight ½-in. insulating board, with a central compartment for dry ice; its cost is less than 50 cents.

Conclusion

Bacteriological examination of water, if done correctly, is a time- and money-consuming process, which is valueless and misleading unless proper care is taken to get the specimens to the laboratory in condition fit for examination. Although it is recognized that bacteriological examination should be carried out immediately whenever possible, economic factors may interfere more often than not. Only the largest treatment plants maintain bacteriological laboratories, and even then results are misleading and valueless unless the work is carried out by a trained bacteriologist adhering strictly to *Standard Methods* requirements.

In any event, the following practicable procedures are recommended for shipping samples:

1. Mark the date and hour of collection plainly, as well as other pertinent information, on a history form accompanying each sample.

2. Study transportation schedules, and so arrange collection times that all water specimens will reach the examining laboratory within 48 hours after collection, and preferably within 24 hours.

3. If the results of unrefrigerated samples from public drinking water supplies show coliform indexes greater than 2.2, collect additional samples from representative points in the water system, refrigerate during transit to the laboratory, and send them to the laboratory by whatever means is necessary for delivery within 24 hours after collection.

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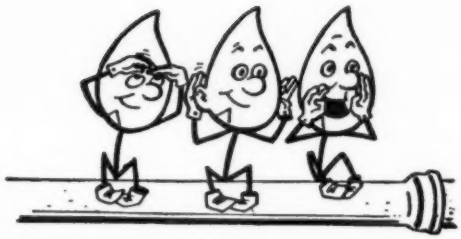

Percolation and Runoff

The onset of a new season gives us hope of a long-awaited weatherlessness. Having just completed the faithful, if not fateful, record of a ten-month heat wave, which gave us 1,398.4 degree-days of excess temperature, and of a three-month drought, which involved a 7.84-in. deficiency of rain, we're ready now to eschew meteorological morbidity in favor of more fruitful fare. Just what that fruitful fall fare will be, we haven't yet discovered, but we're certain enough of its existence to be willing to ignore the provocative report that opening of school on the Channel Island of Jersey has had to be postponed because of the depletion of water supplies in 30 rainless days and to waive mention of the first British rainmaking successes with dry ice. Perhaps it is the aura of autumn that inspires us, but from now on, as far as we're concerned, weather will have to shift for itself.

Speaking of the season, though, and pending the fruition of our other "fare," we ought to point out that *fall*, on the whole, is a pretty poor substitute for *autumn*. Much more precipitous and much less euphonious, *fall* is also a less accurate term. Where *autumn* signifies maturity and decline, *fall* is too final. And if brevity is that important, why not also *die*, *bud* and *grow* (or, this year, *sear*)? No! Rank reactionary though we may be, we'll stick to *autumn*, *winter*, *spring* and *summer;* and if those terms are considered too laboriously extrasyllabic in these hurried days, we'd prefer the personal realism of *sneeze*, *freeze*, *wet* and *sweat*. At any rate, the autumnal equinox has passed and though we admit to maturity and expect to decline, we refuse to fall.

Real "fall" fare, however, is the recent disclosure that our Russian then-allies fared so well at Yalta only because they drank water. Even if it was a W.C.T.Unionist who made the disclosure and even if the water came out of vodka bottles, we would be derelict in our loyalties to ignore such a statement.

We, who fully realize the wonders of water, cannot, of course, subscribe to the negative approach whereby the W.C.T.U. seeks to blame the

(*Continued on page 2*)

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vodka that representatives of other nations drank for their alleged lack of acumen, but are willing to attribute to the water involved some possibly persuasive powers that were not present in the vodka. Thus, rather than agreeing with the contention that "Stalin and the Soviets outwitted the representatives of other nations by plying them with vodka, while the Russians drank water from vodka bottles," we would say that Stalin and the Soviets outwitted those representatives by depriving them of water. And if we're not really convinced that they were outwitted, we certainly won't admit that to the detriment of water.

As a matter of fact, having experienced vodka ourself upon occasion, and remembering how temperate, if not timid, were our repeat performances, we're a little surprised at W.C.T.U.'s attitude toward it. To us, vodka would seem an ideal object lesson in temperance, unless of course the rule of "once bit, twice shy" is inoperative in the Union's by-laws. Come to think of it, too, we're a little confused about even the basic principles of the W.C.T.U. and the apparent intemperance of its own approach, but, then, the essence of being moderate in moderation has always escaped us.

At any rate, if this proves to be another citation of water's powers, we are most grateful to support from a new quarter.

"From Dan to Beersheba," the phrase which has come to mean "from limit to limit" because it expressed the extent of biblical Israel from its northern to its southern extremities, will acquire a new flavor when a 500-acre reservoir floods part of the latter city. The reservoir will supply a new Negeb city which, as it will be erected on the heights overlooking Beersheba, will thus presumably be situated between the desert and the deep blue sea. Source of the water will be the damming of the Wadi Saba, a rocky watercourse through which over two and a half bil.gal. of runoff pour into the Mediterranean every winter. Work on the $4,000,000 project now awaits approval of plans by TVA engineer John L. Savage.

Men or moose, we need our drinking water. Thus, when Minnesota's 3,000-sq.mile "great bog" moose range dried up this year, a thirsty appeal for help was sent through the State Division of Game and Fish to water-wise Navy. In no time at all, the moose call reached the ears of naval fliers at Wold-Chamberlain Field and sent them winging with seven half-ton bombs to blast out as many 100-ft. crater infiltration galleries which will provide not only drinking water, but the deep water protection moose need to escape pestiferous blackflies, deerflies and midges. So another drought bout, which threatened to reduce loose moose or at least make them vamoose, was won by Navy bombardiers.

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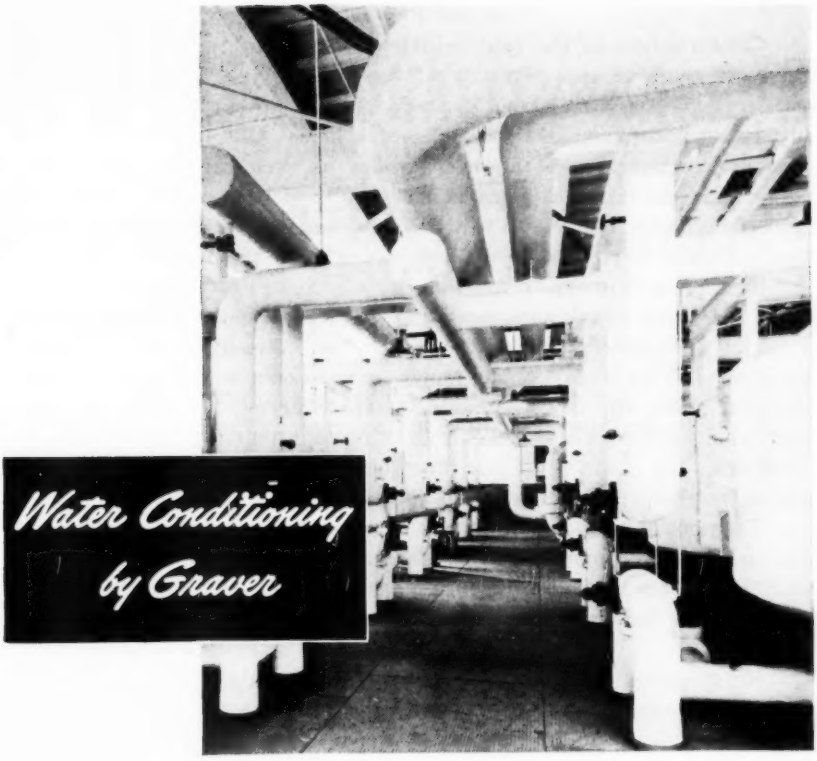

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(*Continued from page 2*)

Conservation of the type which enabled Nutley, N.J., to reduce water consumption approximately 15 mil.gal. last July by curtailment of lawn sprinkling is a creditable kind of consumer cooperation, which, happily, is not uncommon in the water works field. Unsolicited cooperation from unexpected sources, however, makes us even happier, particularly when the conservation involved has a promise of permanence. Thus, we can drop a curtsy this month to the Army Signal Corps and the Western Pacific Railroad Co. for at least a couple of drops in the bucket.

First pleasure measure was that introduced at Fort Monmouth, N.J., where the Signal Corps announced a new photographic developing process involving a 96 per cent reduction in water use. Aimed primarily at making it possible for mobile photographic units to operate in desert or other waterless areas, the new technique involves filtering and reuse of print wash water, so that where 250 gal. were formerly required 10 will now do. Good news too is the word that other branches of the military service as well as the photographic industry itself are contemplating use of the process.

Then out in Nevada and Utah, where water is one of the scarcer commodities, thirsty communities are cheering the news that, when the Missouri Pacific completes its dieselization program in 1950, large quantities of water now being used by steam locomotives will be given back to the consumers.

Next month, who knows, it may be the paper industry's turn to get on the waterless wagon, or at least to turn to a different source. What a boon to conservation it would be, for instance, if an Eaton's Salt Water Vellum, an Atlantic's Ocean Ripple and a Hammermill's Saline Bond were to replace the present freshwater sheets. And, in these hayfeverish days, consider the saving in potable supplies if Tidewater Tissues were to be substituted for Kleenex and its kompetitors.

Actually, with conservation a more and more important factor in the water works field, we're not even above extolling the present preference for *salt water* taffy.

Still more conservational than we, our British cousins have long battled hard to discourage waste and to reduce consumption. Thus, the news that the British Ministry of Health has considered trebling of one type of domestic consumption in the last ten years "a good sign" should come as rather a shock. Learning that that increase involved the rise in hot water use from 6 to 18 gpd. per average British family, however, adequately insulates us. With the Ministry, we certainly can agree that any such indications that people are taking more baths must be a healthy sign. As a matter of fact, the sooner we get over our Nineteenth Century Saturdaynightis, the better—and not only because it will mean the elimination of another peak load either.

(*Continued on page 6*)

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(*Continued from page 4*)

The war on stream pollution is being pushed fiercely on several fronts. Signing of the Water Pollution Control Act (August 1948 JOURNAL, p. 899) on June 30, 1948, by President Truman, which until now has provided largely moral support to clean-up advocates, is beginning to take shape as a real force as the preliminary machinery gets under way. The first report of the Water Pollution Control Advisory Board, recently set up under the Act (April 1949 JOURNAL, P&R p. 6) called for its "aggressive implementation." Meanwhile provisional allotments totalling $850,000 have been made by the Federal Security Agency for grants, under the terms of the Act, to the various states, territories and the District of Columbia for pollution studies.

On the local scene—if the eight-state Ohio River Valley Water Sanitation Commission can be called local—latest evidence of the implementation of the year-old antipollution compact (August 1948 JOURNAL, P&R p. 2) is the news that a $25,000,000 sewage disposal program is being planned by Cincinnati, and that blueprints for the works are being revised to provide a degree of treatment that will meet the commission's high standards. The project is being financed by a surcharge on water service, and already $1,500,000 has been collected in this manner. In addition, nineteen nearby cities and villages have agreed to join in the construction program.

Elsewhere acceleration of the clean-up program is being evidenced by such events as the appointment of Anselmo F. Dappert, principal sanitary engineer of the New York State Dept. of Health since 1930, as executive secretary of the newly formed State Water Pollution Control Board (June 1949 JOURNAL, P&R p. 56). Previously, acting secretary Earl Devendorf had advised 87 communities which discharge untreated or inadequately treated sewage into state waters to take advantage of existing aid, in the form of state funds, for planning treatment works. Provision for such aid under existing law will terminate on April 1, 1950.

Finally, announcement of the Fifth Industrial Waste Conference, to be held at Purdue Univ., Lafayette, Ind., on November 29–30, focuses attention on a subject of ever-widening interest. The registration fee is $4.00, and further information can be obtained from Don E. Bloodgood, who is serving as chairman of the conference.

Almon L. Fales, consultant and former partner in the Boston firm of Metcalf and Eddy, died on August 19 at Newton Center, Mass. He was 73 years old. A graduate of Worcester Polytechnic Inst., Class of 1898, Fales was connected with the Worcester sewage works until 1913, when he held the position of superintendent and director of the testing laboratories. In that year he began his association with Metcalf and Eddy, specializing in sanitary engineering, stream pollution control and treatment of sewage and industrial wastes.

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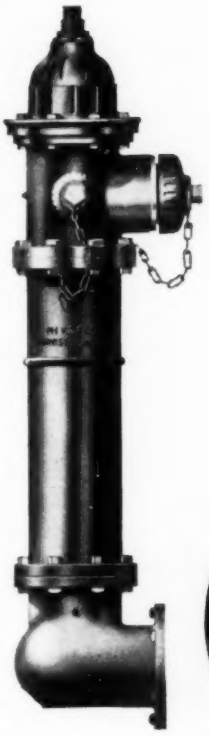

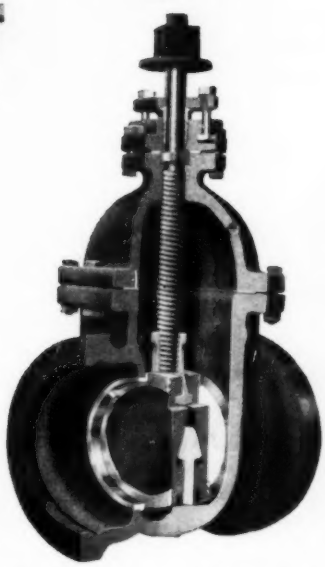

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(Continued from page 6)

Philip E. Bond, head of the consulting engineering firm of Tighe and Bond, of Holyoke, Mass., died at that city on August 18, at the age of 55. He had received his engineering education at the Univ. of Michigan, later attending the U.S. Naval Academy and serving as an officer during World War I. Among the civil posts he held were that of engineer of Hampden County, Mass., and city engineer for Holyoke.

C. J. Des Baillets, chief engineer for the Verdun, Que., Engineering Div., died on August 26, after a period of illness caused by a heart ailment. He had been Chairman of the Canadian Section and in 1945 received its Fuller Award.

W. C. Morse, superintendent of the Seattle Water Dept., died suddenly on September 21, at the age of 75. His early career in mining and hydraulic engineering was interrupted by service in World War I, but on his return he soon established a practice as a consultant in hydraulics. In 1927 he was appointed City Engineer for Seattle but resumed his private position a year later. He was appointed superintendent of the water department in 1938 and held that post with singular distinction until his death. From 1944 to 1947 he served as A.W.W.A. director from the Pacific Northwest Section.

W. O. Myers, superintendent of the Ottawa, Kans., Water and Light Dept., died on August 27, at the age of 67. He had been presented with the Kansas Section's Fuller Award at the recent Chicago conference for his managerial ability and his work in promoting sanitary quality and fluoridation research.

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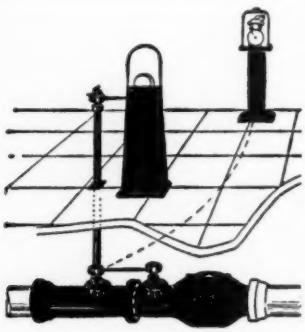

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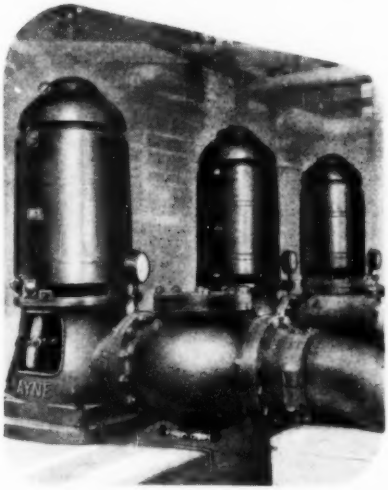

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WELL WATER SYSTEMS

(*Continued from page 8*)

Paradise isn't lost! Its deed, as given by the Angels, is even now held by the New ark (Newark, that is, N.J.) Water Department. Moreover, its lack of populace, or even visitors, is logically explained by the fact that the department has incorporated Paradise into its Canistear watershed, and thus posted it liberally with "No Trespassing" signs.

True, Paradise is merely the name of a no longer existent small hamlet on the city's watershed; true, too, that Angel was merely the name of the family from whom the property was purchased. But we, as New Yorkers, who fight out our existence within sight of the Hell Gate Bridge, are firm believers that there is *something* in a name.

Paradise is lost, however, as far as the New Jersey Audubon Society is concerned—at least if we are to take seriously the plaintive report of its editor, one David G. Fables. In most sections of the state, protests Mr. Fables, "a person cannot set foot on the land to study a moss, photograph a flower, or even to breathe!" And taking "the case of the watershed and reservoir system of one of our large cities," he points out that "miles and miles of attractive land are posted against trespass for any reason simply because one city controls the area." Without ever having had an inclination "to study a moss," we're inclined to agree with Mr. Fables' conclusion that his "salvation" seems to lie in state forests and parks. At least in those areas, some measure of control can be exercised over visitors less scrupulously nature-loving than members of the Audubon Society. And Mr. Fables, we are sure, is with us in wanting to keep at least some of our nonAudubonists away from the source of our drinking water, by whomever controlled.

"If I had a million dollars" became a reality for residents of Perryopolis, Pa., about a year ago when the will of a former resident contributed $1,320,000 to the town for "general civic improvement." It has taken Perryopolitans a full year to decide just what they would do, and now we're ready to applaud their decision, for ranking tops, and equal with "education," is a water and sewage system, budgeted at a cool quarter of a million. Among the other specific projects blueprinted are improvements to streets and highways, a municipal building, shade trees and parks and street lighting; and, by stipulation, half the bequest is to be invested in interest-bearing bonds. But, since money does talk big, the evidence of appreciation of public water supply is unmistakable.

John J. Carroll, since 1939 the Indiana representative for Neptune Meter Co., has been appointed district manager of the Louisville, Ky., office to succeed the late Edwin L. Cantrell. He has been associated with the company since 1937.

(*Continued on page 12*)

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(*Continued from page 10*)

The final official count of constitutional amendment ballots brought last month's interim 1,673 (see Sept. P&R, p. 1) up to a gratifying total of 1,861, 25.7 per cent of total eligibles everywhere, with voters from every state, province and section, from as far away as England to the east and Hawaii to the west. And with the negatives at a mere 21, 1.1 per cent of the total, the A.W.W.A. Executive Committee had little trouble in declaring the amendment officially approved.

Adding to the official count, a too-late tally of 14, we can now pass out a round, 1,875 congratulations and thank-yous. We are, and think you, too, should be, more than happy about the whole thing.

Everything's Jake these days with the New York *Daily News*—Jake Van Atta, that is, of the Ralph B. Carter Co. Only last January, water works Jake was guest counselor on a "how to win friends" panel in the *News'* Inquiring Fotographer column, and now in August he's popped up again, this time televised by the *News'* Station WPIX as an authority on deep sea fishing. Where next our Jake of all trades will spread his extracurricular expertness we have no idea, but we're keeping an eager eye on the *News'* lovelore and menus.

(*Continued on page 14*)

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Under the cover reproduced herewith, A.W.W.A. has, in response to the demand of several meter departments, reprinted Bruce McAlister's "Bow-wow, Mister Meterman" as it appeared in the July issue of **Public Relations at Work.** As a six-page booklet, this practical advice to the doglorn is now available at a nickel per copy—much less than the cost of a single patch in the seat of your pants.

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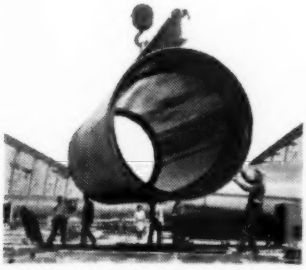

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*Reg. U. S. Pat. Off.

(*Continued from page 12*)

For "October," read "September." Every year about this time, we smash another crystal ball and 'fess up our inability to keep you adequately newsed. It's not only the fact that we can't in early September give you the scores of October's World Series games, it's the fact that we can't even talk about who played or, indeed, indicate that there really was a World Series. Back in the August issue, we talked about a drought and received our copy rain-soaked. In September, we complained about the heat and practically had to chip the ice off our mailbox to get at the finished product. And now in October, we're a little more than despondent, for it really is September and what we say must remain ungainsaid.

Ivan M. Glace, the well-known Harrisburg, Pa., consultant who was one of the organizers of the Pennsylvania Water Works Operators Assn. 22 years ago, and who has served as its Secretary ever since, has relinquished that position at the society's August meeting. Instead he will take up the less burdensome duties of Second Vice President and member of the board. The post of Secretary will be filled by Robert E. Stiemke, professor of sanitary engineering at Pennsylvania State College.

(*Continued on page 16*)

NEW HELLIGE COLOR DISC FLUORIDE

EMPLOYING
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GLASS COLOR
STANDARDS

The color disc is for use with the Hellige Aqua Tester No. 611 and contains ten glass color standards representing 0 0.1 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 p.p.m. Fluoride (F^-). The method is based on the formation of a slightly ionized complex with zirconium.

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Kupferle Fire Hydrants say "Yes" to every requirement. Tested and approved by Fire Underwriters. Meet A.W.W.A. requirements. Proven in use. Will never be an orphan. Send for specifications of entire line.

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FOR WATER AND SEWAGE TREATMENT CHEMICALS

Wallace & Tiernan is proud to offer this machine, proven by nine years' experience in the flour, grain, and chemical industries, to those water works operators who desire maximum accuracy, simplicity, and dependability in dry chemical feeding equipment.

WHAT THE FEEDER DOES—Feeds continuously and accurately at rate selected by operator—Scale beam calibrated in pounds per unit of time—Once rate is chosen, feeder automatically adjusts itself to that rate, thus eliminates calibration regardless of material fed — Quantity of chemical fed recorded on tally unit.

HOW IT WORKS—Feeds BY WEIGHT using constant speed belt drive with variable speed screw feed section, thus eliminates inherent inaccuracy of variable belt speed method.

ADVANTAGES—Totally enclosed motors, oil seals on all bearings, oil baths for drive gears, dust-tight beam enclosure —Provides minimum maintenance and insures high accuracy of feeder for life of machine—Adaptable to program or proportional control—Alarm systems can be added—Wide range up to 2 cu. ft./min.—Extreme accuracy provides maximum economy in feeding of chemicals.

Communicate with your nearest W&T representative and he will gladly furnish you with complete information on the W&T Merchen Scale Feeder.

WALLACE & TIERNAN COMPANY, INC. M-12

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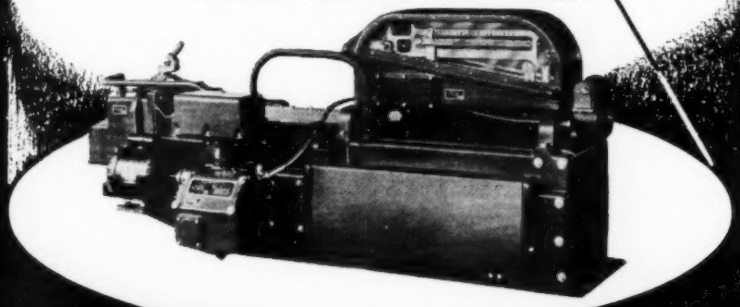
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES



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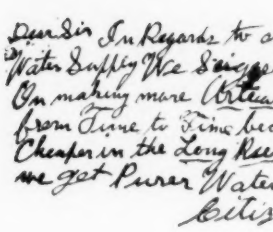

Dear Sir In Regards to More Water Supply We Suggest to Keep On making more Artesian Wells from Time to Time because its Cheaper in the Long Rees and we get Purer Water
Citizens

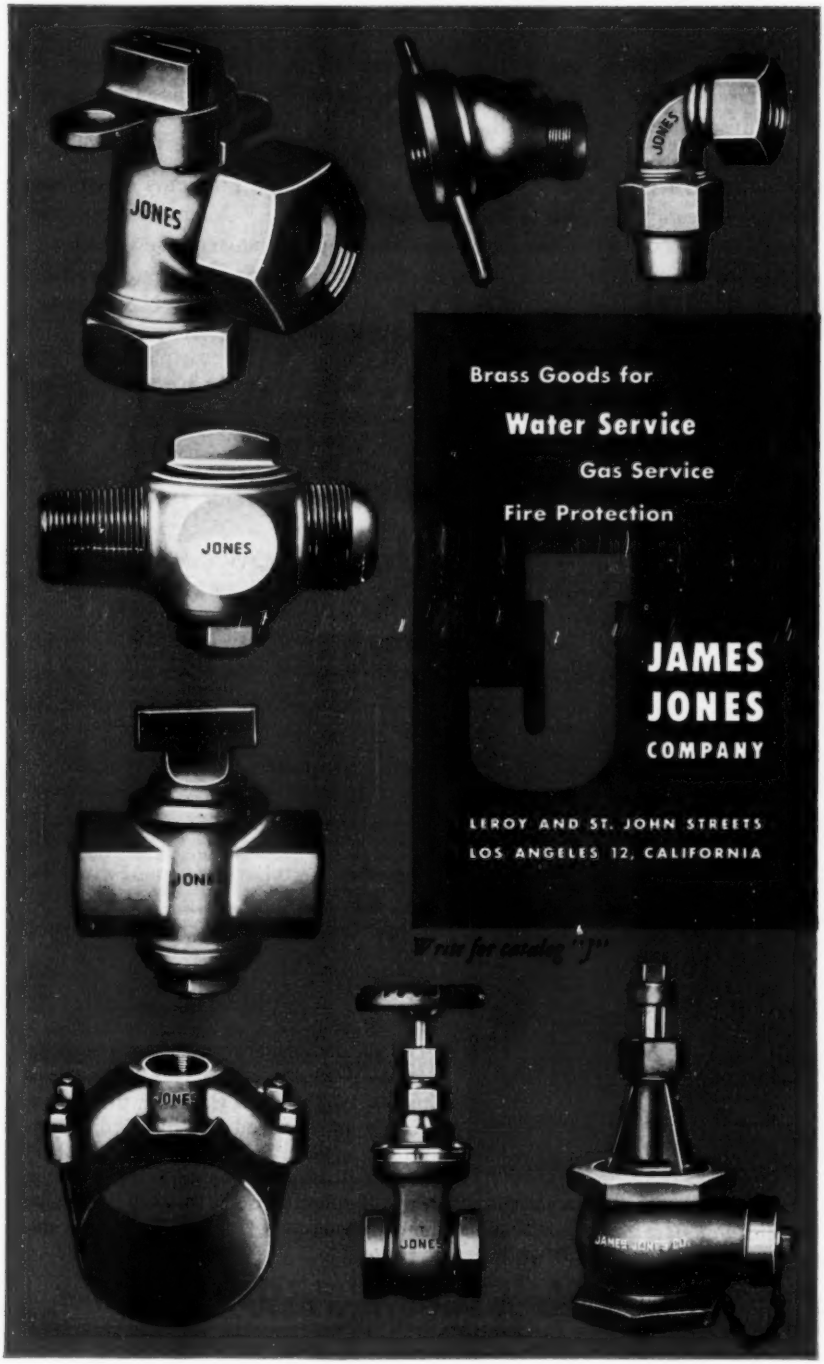
Quacks, cranks and sundry screwballs, always ready with suggestions, criticism or advice, afflict officials in every form of public life. And not least among those afflicted are our water superintendents, who receive an undeserved share of illiterate advice, illegible abuse and ill-mannered complaint. Just how to handle these unsolicited communications is always a difficult question. Most officials share the view that "a soft answer turneth away wrath," but what, they want to know, turneth away impractical benevolence? Fortunate indeed are those who, like Bill Schnabel of Allentown, Pa., receive anonymous and thus unanswerable assistance (see cut). But others, such as Tom Skinker at St. Louis, have found themselves saddled with psychotics, whose proper handling would require more than a casual command of psychiatry. True, it's all in a day's work, but all the more reason why we prefer the life of a more or less private crank.

A new edition of the De Laval Engineering Handbook, edited by Austin H. Church and Hans Gartmann, has just been issued. Attractively bound in blue leatherette, the 278-page book contains a 100-page section of general mathematical and engineering reference data, charts and tables, plus separate sections on steam turbines, centrifugal and Imo pumps, centrifugal compressors, helical and worm reduction gears. In addition, the De Laval catalog is presented in a 20-page supplement. Although necessarily oriented toward the equipment in the catalog, the reference section contains a wealth of useful and valuable data which justifies its cost. The book may be obtained from the Advertising Dept., De Laval Steam Turbine Co., Trenton 2, N.J., at a cost of $2 each.

The Earthworm line of boring machines has been improved and perfected to permit the laying of pipelines of all types up to 3 in. in diameter for lengths up to 150 ft. without the need for breaking surface ground. In many applications, it is possible to use pipe or conduit as drill stem section and leave it underground as a permanent installation, according to the manufacturer, Lube Jack Co., 1415–15th St., Santa Monica, Calif. In operation, water is forced through the drill stem to serve as a lubricant and wash back the cuttings. Accuracy for the maximum distance is said to be maintained within an inch of the target area.

Albright and Friel, Philadelphia firm of consulting engineers, is moving to larger quarters at 121 S. Broad Street, Philadelphia 7, Pa.

(*Continued on page 18*)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LEROY AND ST. JOHN STREETS
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Write for catalog "J"

(*Continued from page 16*)

Jack E. McKee, partner in the consulting engineering firm of Camp, Dresser and McKee of Boston, has been appointed associate professor of sanitary engineering at the California Institute of Technology. He will withdraw as an active partner in the consulting firm, but will remain affiliated with it and will continue to assist it on problems of stream pollution investigation and industrial waste research. A graduate of the Carnegie Institute of Technology, McKee received master's and doctor's degrees for his work in sanitary engineering from Harvard Univ. He has been employed by the Tennessee Valley Authority and the U.S. Public Health Service, and served as an engineer officer during the war.

A new water distribution system is being planned by the village of Pine River, Minn. Hitchcock & Estabrook have been engaged as consultants.

John S. Warde of West Brighton, Staten Island, N.Y., is reported to have died recently. He had been an invalid for some time before his death. His retirement in 1941 ended 40 years of service as eastern sales representative for Rensselaer Valve Co.

A solution to the perennial problem of the snow-covered hydrant which is never located until after the fire is offered by the Highway Marker Div. of American Metal Products Co., 34 Southbridge St., Worcester 8, Mass. Consisting of a 7-in. luminescent red or red enamel flag at the end of a 3- or 4-ft. steel rod, the "Sno-Mark" locks into a universal bracket which can be permanently attached to any hydrant. The marker itself may be removed to minimize wear during the warmer seasons.

The Graver Water Conditioning Co. has been formed by the Graver Tank & Mfg. Co., Inc., to expand the operations of its water conditioning and process equipment department.

(*Continued on page 22*)

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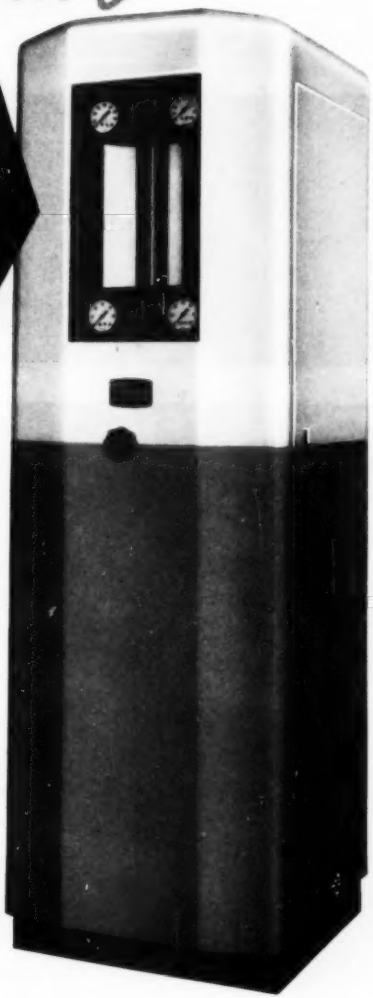
BUILDERS *Chlorinizer*

MODEL CVS

CHLORINE GAS FEEDER



Builders Vacuum Type Chlorinizer for metering chlorine gas and producing chlorine-water solutions is accurate, safe, and simple to operate. It is a thoroughly field tested product of Builders-Providence, Inc., a Company that has specialized in equipment for metering and controlling flow for more than 55 years, and with whom excellence in design and manufacture has been a tradition since 1820.

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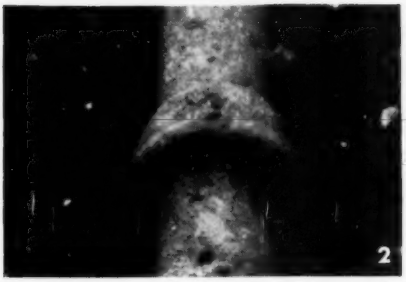
A COMPLETE LINE

The Chlorinizer is also available in another volumetric model, DVS, and in a gravimetric model, CGS. Bulletins on request.

BUILDERS PROVIDENCE *Instruments*



(1) This 101-year-old cast iron water main is serving Frederick, Maryland.

(2) Still in use after 118 years of service in the water supply system of St. Louis, Mo.

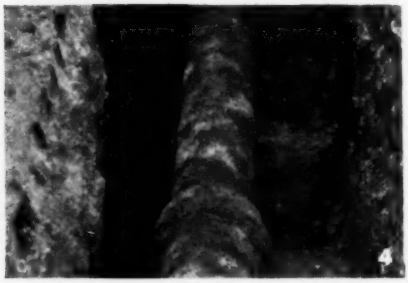
(3) This water main, installed 117 years ago, is still serving Richmond, Va.

(4) Lancaster, Pa. laid this cast iron water main 105 years ago. It is still serving.

(5) One of several cast iron water mains that have been serving New York City for more than a century.

(6) America's oldest cast iron water main, now in its 128th year of service in Philadelphia.

(7) This cast iron water main has been serving Boston for 120 years.



CAST IRON PIPE

Going strong in their 2nd Century

About 30 of the older American cities have cast iron water or gas mains in service which were laid from 100 to 132 years ago. Most of these mains, on or after their 100th Anniversary, have been uncovered, inspected and photographed for the record. Seven of them—all water mains, are shown in this advertisement.

While it is well known that cast iron water mains in England, France and Germany have service records that approach three centuries, we, who make cast iron pipe, nevertheless get a thrill out of looking down into the trench at an uncovered section of a main that has been in service for 100 years—and so, we are told, do water works and gas engineers.

When one considers the radical changes which have occurred in a century in vehicular traffic, and the vast development of underground construction for the many utility services, the fact that these mains are now in their second century of service is all the more remarkable. Cast Iron Pipe Research Assn., T. F. Wolfe, Engr., Peoples Gas Bldg., Chicago 3.

SERVES FOR CENTURIES

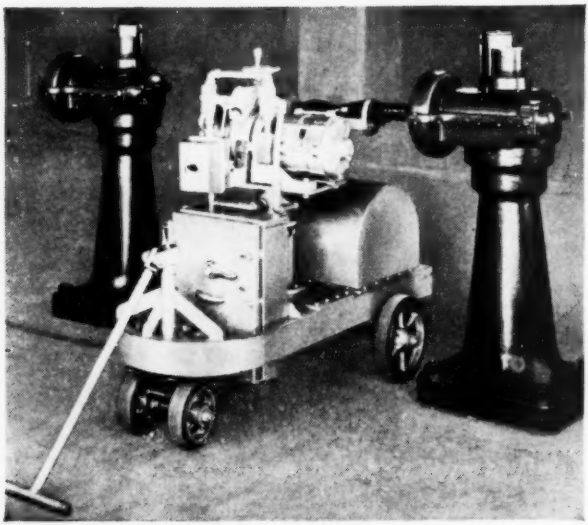
(*Continued from page 18*)

A series of new alkalinity test papers developed by the LaMotte Chemical Products Co., Towson, Md., may be used to differentiate between caustic, carbonate and bicarbonate alkalinity in water and solutions. A compact and inexpensive kit containing three vials of indicator papers and instructions for their use is available and is expected to find use wherever it is necessary to control the alkalinity of treated water.

A new steel plant containing three open hearth furnaces with a capacity of 400,000 tons per year will be built by Armco Steel Corp. at Middletown, Ohio. Construction work on the site, which is just south of the existing East Works plant, will be started as soon as a 500,000-cu.yd. slag mountain is moved off it. The addition is expected to provide a more adequate steel supply in the region.

New squirrel cage induction type motors especially designed for deep well turbine pumps have beeen developed by Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa. The new type CSP Life-Line motors offer 1 to 20 hp. and require 208, 220,440 or 550 .. at 60, 50 or 25 cycles. They can be furnished as a complete motor, a motor without base, or as a stator and rotor only.

LIMITORQUE "*PORTABLE*" VALVE OPERATOR



New . . . the well-known, widely used *"Limitorque"* Motorized Valve Operator, in *Portable form* . . . for use wherever a hand-drawn truck CAN BE WHEELED TO Valve or Sluice Gate location May be quickly connected to power outlet . . . and automatic *electric opening and closing is readily secured.*

Portable "LimiTorque" is equipped with famous *torque-limiting feature* (operates in Opening and Closing directions); *Limit switch* may be set for any travel (automatic resetting); *Universal Joint* connection for compensation of misalignment between floorstand and power unit.

This unique electrical valve operation is *another first* for Philadelphia. It embodies the salient and proven features that have made *"LimiTorque" Valve Operators* the most widely used in the world.

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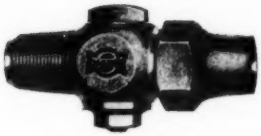
ERIE AVE. AND G STREET **PHILADELPHIA 34, PA.**
Manufacturers of Industrial Gears, Speed Reducers, LimiTorque Valve Controls
NEW YORK . HOUSTON . PITTSBURGH . CHICAGO

Send for 96 page "Limitorque" Catalog and please use your Business Letterhead when requesting same.

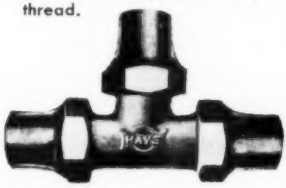
For Complete Service . . .



CATALOG No. 5200
Hays Corporation Stop with inlet A. W. W. A. standard thread.

HAYS

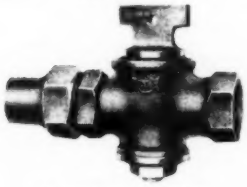
WATER WORKS PRODUCTS



CATALOG No. 5622
Hays Tee for copper to copper to copper connection.

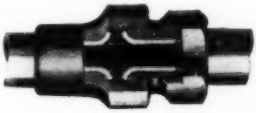
HAYS Manufacturing Company is one of the largest making a complete line of water service products, and for 80 years has enjoyed the prestige earned by unremitting insistence upon high quality. The HAYS line of fittings and other products is famous throughout the world for easy installation and a long life of trouble-free service.

All HAYS water works fittings are interchangeable with those of other manufacturers and corporation stops can be installed with any standard tapping machine equipment. They are made of highest quality 85-5-5-5 bronze, plugs are ground for perfect fit, specially lubricated for permanent easy turning, and hydrostatically tested at 200 pounds or more. Write for the new HAYS catalog showing the complete HAYS line of water works products.



CATALOG No. 5050
Hays Curb Stop for iron pipe to copper service connection.

CATALOG No. 5628
Hays Elbow for Male iron pipe to copper connection.



CATALOG No. 5610
Hays Two Part Union for copper to copper connection.

CATALOG No. 5605
Hays Coupling for Male iron pipe to copper connection.

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Membership Changes

NEW MEMBERS

Applications received August 1 to 31, 1949

Aalto, Johan A., Civ. Engr., New York City Dept. of Water Supply, Gas & Elec., Box 908, Kingston, N.Y. (July '49)

Anderson, Merlin H., *see* General Filter Co.

Angleton, Wilfred R., *see* Indiana Girls School

Arighi, Ernest J., Supt., Water Works, City Hall, City Bldg., Kent, Ohio (July '49)

Aycock, A. R., Mgr., Water & Light Dept., Tupelo, Miss. (July '49)

Bradbury, James G., Chief Engr., Hays Mfg. Co., 12th & Liberty Sts., Erie, Pa. (July '49)

Carle Place Water Dist., Edward Dolegoski, Maintenanceman, 453 Westbury Ave., Carle Place, N.Y. (Munic. Sv. Sub. July '49) *M*

Carroll, Thomas M., Mgr., Water Well Drillers Assn. of Southern California, 408 S. Spring St., Los Angeles 13, Calif. (July '49)

Cary, Edmund Shepard, Asst. San. Engr., Bureau of San. Eng., State Dept. of Public Health, 2180 Milvia St., Berkeley 4, Calif. (July '49)

Coe, Russell H., *see* Pittsburgh Coke & Chemical Co.

Coggin, Benton G., Jr., Assoc. Engr., Leland B. Cook, Cons. Engr., Box 49, Nettleton, Miss. (July '49) *PR*

Colonial Mills, Inc., Clarksville Finishing Div., V. T. Fahringer, Chief Engr., Clarksville, Va. (Corp. M. July '49) *MPR*

Dell, Charles F., Supt., Water Works, Munic. Water Utility, Black River Falls, Wis. (July '49) *MPR*

Dolegoski, Edward, *see* Carle Place Water Dist.

Dominion Utilities Co., Ltd., C. M. Smyth, Gen. Supt., Sydney, N.S. (Corp. M. July '49)

Dooley, Fouts M., Sales Repr., McKesson & Robbins, Inc., 2011—56th St., Des Moines, Iowa (July '49)

Drago, John O., Supt., Water Dept., W. Spruce St., Ravenna, Ohio (July '49)

Dunn, Wheeler W., Jr., Water Works Contractor, Box 271, R.F.D. No. 8, Jackson, Miss. (July '49)

Elsea, Edgar E., Supt., Pittsburgh Pipe Cleaner Co., 214 Euclid Ave., Birmingham 9, Ala. (July '49)

Erie County Water Authority, John Horner, Chairman, 336 Ellicott Square Bldg., Buffalo 3, N.Y. (Corp. M. July '49)

Fahringer, V. T., *see* Colonial Mills, Inc.

Feuille, Fred, Dist. Engr., W. H. & L. D. Betz, 417 Olive St., Park Hill, North Little Rock, Ark. (July '49) *MP*

Fort Frances, Town of, J. W. Walker, Town Clerk, Fort Frances, Ont. (Corp. M. July '49)

Gannon, Timothy J., Asst. San. Engr., Bureau of San. Eng., State Dept. of Public Health, 6447 Regent St., Oakland, Calif. (July '49) *MP*

General Filter Co., Merlin H. Anderson, Vice-Pres., 923—2nd St., Ames, Iowa (Assoc. M. July '49)

Godwin, Hugh L., Field Engr., Fairbanks, Morse & Co., 930 E. Adams St., Jacksonville 1, Fla. (July '49)

Haven, Robert C., Jr., The Francis Eng. Co., 1019 Ludington St., Escanaba, Mich. (July '49) *MPR*

Hawke, Lowell L., Supt., Oak Lodge Water Dist., Box 226, Oak Grove, Ore. (July '49) *M*

Hazelswart, Donald E., Supt., Munic. Water Works, 813 Washington Ave., Defiance, Ohio (July '49)

Hecht, E. W., Sales Engr., Finley's Municipal Supply Co., 1133 W. Church St., Orlando, Fla. (July '49)

(Continued on page 30)

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(*Continued from page 28*)

Hoffman, Donald A., Chemist, Board of Water & Elec. Light Comrs., 608 W. Lapeer St., Lansing 15, Mich. (July '49) *MR*

Hollowell, C. Q., Supt., Light, Water & Sewage Dept., Leland, Miss. (July '49)

Holman, H. C., Cons. Civ. Engr., 234 W. Harding Way, Stockton, Calif. (July '49)

Horner, John, *see* Erie County Water Authority

Indiana Girls School, Wilfred R. Angleton, Chief Engr., R.R. 2, Box 440, Indianapolis 44, Ind. (Corp. M. July '49) *MPR*

Jessup, Warren Clinton, Operating Engr. Water, U.S. Army, Post Engrs., Camp Stoneman, Pittsburg, Calif. (July '49) *P*

Kaufman, Herbert L., Engr., New York Water Service Corp., 90 Broad St., New York, N.Y. (July '49) *MP*

Kelly Pipe Co., C. E. Ulrich, 525 N. Mission Rd., Los Angeles 54, Calif. (Assoc. M. July '49)

Kenyon, J. A., Pres., Soft Water Service Co., 917 N. Main, Pueblo, Colo. (July '49)

La Conga, Jack F., Resident Engr., 7th Infantry Div. Artillery, APO 7, Unit 4, c/o Postmaster, San Francisco, Calif. (July '49) *M*

La Riva, Jose Herrera, Director-Supt., Acueductos del Depto., Instituto Nacional de Obras Sanitarias, Vargas, Maiquetia, Venezuela (July '49) *MPR*

MacPherson, William, Chem. Engr., The Semline Corp., Box 268, Iloilo City, Philippine Islands (July '49) *MP*

Massey, George B., Cons. Engr., 53 W. Jackson Blvd., Chicago 4, Ill. (July '49)

O'Hare, Don R., Engr., Wallace & Tiernan Corp., 654—46th St., Des Moines, Iowa (July '49)

Perreault, Arthur W., Supt., Water Dept., 27700 Gratiot Ave., Roseville, Mich. (July '49)

Pitman, Ike W., Salesman, Neptune Meter Co., Box 1048, Jacksonville, Fla. (July '49)

Pittsburgh Coke & Chemical Co., Russell H. Coe, Mgr., Protective Coatings Div., 1905 Grant Bldg., Pittsburgh, Pa. (Assoc. M. July '49)

Randall, Fred, Water Technician, Pennsylvania Salt Mfg. Co., Wyandotte, Mich. (July '49)

Richardson, H. C., *see* West Genesee Water Service Corp.

Rorabaugh, Matthew I., Dist. Engr., U.S. Geological Survey, Ground Water Branch, 531 Federal Bldg., Louisville 2, Ky. (July '49)

Royal Oak, City of, George G. Schmid, Water Supply Engr., 221 E. 3rd St., Royal Oak, Mich. (Munic. Sv. Sub. July '49) *MPR*

Schmid, George G., *see* Royal Oak, City of

Sicken, Francis J., Chief Operator, Filtration Plant, 229 Water St., Marine City, Mich. (July '49) *MP*

Simpkins, Charles H., Operator, Water Purif. Plant, 508 Summit St., N.W., Warren, Ohio (July '49)

Smith, Patrick Benton, City Engr. & Mgr. of Utilities, Coffeyville, Kan. (July '49) *MP*

Smyth, C. M., *see* Dominion Utilities Co., Ltd.

Stewart, A. Paul, Chief Engr., Water Filtration & Pumping, R.F.D. No. 3, Ravenna, Ohio (July '49)

Stone, L. L., Pres., L. L. Stone, Inc., E. 45th St., Lawrence, Ind. (July '49) *PR*

Ulrich, C. E., *see* Kelly Pipe Co.

Vernier, Albert J., Supt., Ira Township Water Dept., Fair Haven, Mich. (July '49) *M*

Vokoun, Harold J., Asst. County San. Engr., Lake County Water Dept., Courthouse, Painesville, Ohio (July '49)

Walker J. W., *see* Fort Frances, Town of

Wallace, Keith K., Civ. Structural Engr., Board of Water Supply, 3122 Huelani Drive, Honolulu 54, Hawaii (Oct. '49)

Washburn, Cyrus, Jr., Chief Engr., Elec. & Water Eng. Dept., Utilities Bldg., Jacksonville, Fla. (July '49)

Wesson, Michael M., Sales Engr., Peerless Pump Div., 1623—12th St., S., Birmingham, Ala. (July '49)

West Genesee Water Service Corp., H. C. Richardson, Pres. & Treas., 115 Wilshire Rd., Syracuse 9, N.Y. (Munic. Sv. Sub. July '49) *M*

White, Albert, Dist. Mgr., Pittsburgh Pipe Cleaner Co., 214 Euclid Ave., Birmingham 9, Ala. (July '49)

(*Continued on page 32*)

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(*Continued from page 30*)

Whitnack, Kenneth S., Administrative Aid, Water Dept., 215 W. Broadway, Long Beach 2, Calif. (July '49) *M*

Willman, W. K., City Mgr., Port Huron, Mich. (July '49) *M*

REINSTATEMENTS

Asketh, Jordan S., Caisson Wells, Inc., 33 W. 42nd St., New York 18, N.Y. (Jan. '46)

Blanch, Osvaldo, San. Engr., C. A. Oficina Tecnica de Ingenieria, Urbanizacion San Antonio, Calle Olimpo No. 16, Valencia, Venezuela (Jan. '42)

Lavigne, Wilfrid, Supt., Water Works & Elec. Plants, Box 40, Ste. Anne de Bellevue, Que. (Apr. '47)

Lundell, George R., Jr. Chemist, Water Dept., Columbia Heights Filtration Plant, 4500 Reservoir Blvd., Minneapolis 21, Minn. (Aug. '27) *P*

Matheny, H. B., *see* Remington-Rand, Inc.

Remington Rand, Inc., H. B. Matheny, Mgr., Public Utility Dept., 315—4th Ave., New York 10, N.Y. (Assoc. M. Apr. '37)

LOSSES

Deaths

Cantrell, E. L., Dist. Mgr., Neptune Meter Co., 815 W. Market St., Louisville 2, Ky. (Apr. '39)

Mathews, Henry M., Supt., Water & Light Dept., Thomasville, Ga. (Oct. '39) *Director '49–'52. MP*

Owings, Noble L., Asst. to Chief Engr., Washington Suburban San. Com., Hyattsville, Md. (Jan. '23) *M*

Warner, R. B., Mgr., City Water Works, City Hall, Walnut Ridge, Ark. (Jan. '49)

Resignation

Dunlap, David, Regulatory Consultant, 2808 Merion Rd., Camp Hill, Pa. (Oct. '45)

(*Continued on page 34*)

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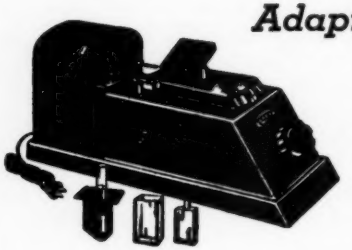

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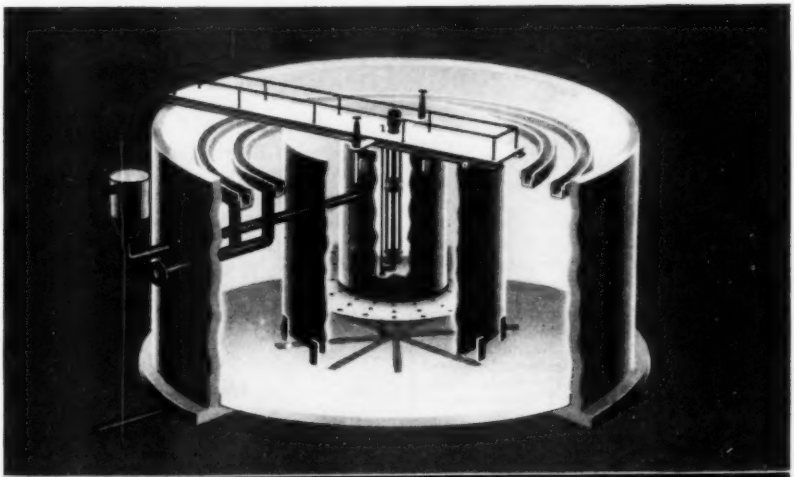

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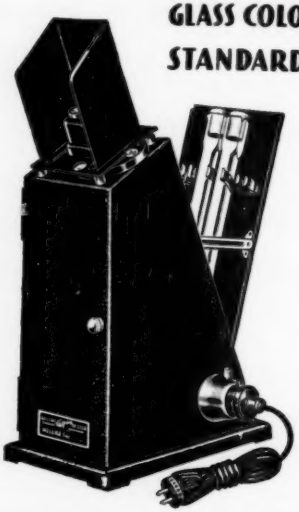

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(Continued from page 32)

CHANGES IN ADDRESS

Changes received between August 5 and September 5, 1949

Ahlgren, Clarence L., Asst. Engr., Water Works, 597 Lake Shore Rd., Manchester, N.H. (Jan. '46) *M*

Ayala H., Juan Pablo, Edificio Aliaza, Monroy a Misericordia, Caracas, Venezuela (Jan. '41)

Bauer, L. G., 1327—8th Ave., San Francisco 22, Calif. (Mar. '31)

Beatty, C. E., 514 Euclid St., Middletown, Ohio (Oct. '45) *MP*

Berkowitz, Sidney A., Bureau of San. Eng., Box 210, Jacksonville 1, Fla. (Jan. '46) *P*

Bradlee, Warren R., 45 Valleywood Rd., Cos Cob, Conn. (Apr. '47)

Castella, William F., Cons. Engr., 1422 Santa Monica, San Antonio, Tex. (Apr. '48) *MPR*

Crawford, Lawrence C., Dist. Engr., U.S. Geological Survey, 46 Northmoor Pl., Columbus 2, Ohio (Jan. '47) *R*

Crepeau, Louis, Cons. Engr., 1058 Bourdoges Ave., St. Hyacinthe, Que. (Jan. '46) *MPR*

Dappert, Anselmo F., Exec. Secy., State Water Pollution Control, Albany, N.Y. (Apr. '31)

Driggs, Richard J., West Coast Dist. Mgr., Dresser Mfg. Div., 204 Davis St., San Francisco 11, Calif. (July '49) *M*

Dunstan, Gilbert Hall, San. Engr., U.S. Public Health Service, Box 750, Fairbanks, Alaska (July '31) *PR*

Fairbairn, John M., Pres., Charles Warnock & Co., Ltd., 21 St. James St., W., Montreal, Que. (Apr. '34) *P*

Fuller, R. P., 15505 E. Whittier Blvd., Whittier, Calif. (Oct. '46) *MR*

Gauld, M. C., Route 1, Box 230 C.V., Bloomington, Calif. (Jan. '49)

Haley, Jess Lee, Jr., Supt., Water & Light Dept., Clarksdale, Miss. (Jan. '48) *M*

Horn, A. John, Chief San. Consultant, Kanagawa C.A.T., APO 503, c/o Postmaster, San Francisco, Calif. (July '39)

Howe, John B., 5289 Toledo St., Long Beach, Calif. (Apr. '49)

Kenney, Norman D., Cons. Engr., 5707 Chilham Rd., Baltimore 9, Md. (Jan. '41) *P*

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Astragalusian Epistle

To my many friends and well-wishers, thanking you for past remembrances, and hoping thereby to save your asking, and my relating, the Episode:

A ladder is a useful thing;
'Twill roof or ceiling closer bring.
While from a rung on topmost step
One works away with vim and pep.

If ladder takes a backward swing,
O brother, that's no time to sing.
This to my sorrow I have found
On top step eight feet from the ground.

Envisioned was a backward fall;
I jumped just to avoid the wall
And where till then all bones were sound
They now with aches and pains abound.

The doctor came and set some splints
And more than once it made me wince.
Stretched out upon a car back seat
To P. G. H.* we did retreat.

The X-ray artist, very glum,
Inferred that accidents were dumb
And grumbled loud in overtones
She guessed there were no broken bones.

"We'll keep you here for overnight,"
Was all they'd tell me of my plight.
The Doc came in next day and said:
"A day or two you'll stay in bed."

An armored boot they then obtained
Because the ankle was so sprained.
(It's on there yet but soon I hope
'Twill serve some other luckless dope.)

The day or two stretched round about
And three weeks passed 'fore I was out.
The broken bones seem on the way
To mend so I may walk some day.

Each morn to see if one's alive
The nurse came in at half-past five
And said: "Wake up, you sleepy-head,
It's time that you sat up in bed."

Then breakfast came at eight o'clock
Dinner 'fore noon—O what a shock!
And supper soon was on the way
At 9:00 P.M. you hit the hay.

The food was good—I've no complaints;
But hours—now they would plague the saints.
And as for traffic, trucks and noise
With governors I'd fix those boys.

And double mufflers I would place
On all the engines that do race
To beat the traffic lights like rabbits
With jumping jive, such foolish habits.

So, folks, if you would have some fun,
All tipsy ladders you should shun;
Unless you too expect a rest
Enforced without your own request.

CHARLES H. CAPEN

Chief Engr.,
North Jersey Dist. Water Supply Com.
Wanaque, N. J.; Aug. 24, 1949

In sympathetic understanding
Of hospitalian ask-withstanding,
We hereby broadcast information
On Capen's discombobulation,
And ask that one and all refrain
From causing any further sprain
Of tongue or tonsil, by requesting
Detail more gory and arresting.

—ED.

* Poetic license for Paterson General Hospital.

(*Continued on page 38*)

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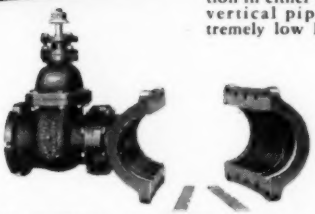

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IOWA GATE VALVES—Simple, rugged construction, fully bronze mounted. Parallel seat, double disc type with independent solid bronze wedges and stem nut. Trouble free service assured.

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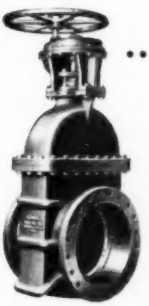

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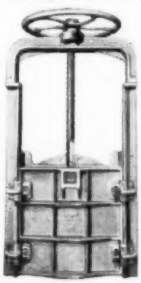

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(Continued from page 36)

Doubt Rout

To the Editor:

Permit me to observe that the water works profession is being a little too brazen when on the cover of its JOURNAL (August issue) it carries a picture of the syphilis spirochete (captioned as *Anabaena*) and lists it as one of the "Fearsome Foursome of August Algae." . . . of course that fearsome organism may be one of the algae, but if it is, it still doesn't look like *Anabaena*. Take a look at a picture of *Spirulina* and see if that organism doesn't have a familiar twist.

THOMAS M. RIDDICK

Cons. Engr. & Chemist
New York, N. Y.; Aug. 19, 1949

To the Editor:

. . . I am unable to agree with the identification of the organism pictured on last month's cover. The *Anabaena* looks a lot more like *Spirulina*, although I am perhaps a little too rash in attempting identification from a reproduction of a photograph.

J. R. ROSSUM

San. Engr.
California Water Service Co.
San Jose, Calif.; Aug. 22, 1949

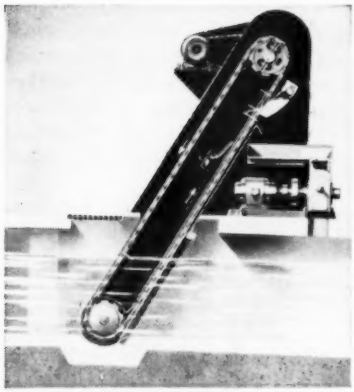
To the Editor:

Noting the comments of Messrs Riddick and Rossum, I wish to assure both gentlemen that the organism in question was correctly identified as *Anabaena*, the type being *flos-aquae* (curly form).

Commenting first on Mr. Riddick's suggestion that the organism could be the syphilis spirochete, *Treponema pallidum*, I wish to point out that the photomicrograph was taken with a 16-mm. objective and a 10-mm. eyepiece, which is relatively low power. At any rate, this power is absolutely too low to bring out *Treponema pallidum*, which

(Continued on page 40)

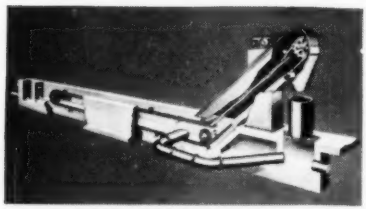
It's a Matter of Record...



Rex Mechanically Cleaned Bar Screens and Triturators

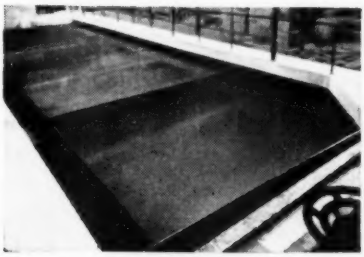
and in plant after plant, the records show that Rex Sanitation and Process Equipment provides unequaled efficiency . . . sets the standards for economical, long-life operation.

Whether it's a large plant or small, a look at the figures will convince you that Rex Equipment is right for your operation . . . primary or complete treatment . . . domestic or industrial waste. Specially trained Rex Sanitation Engineers will be happy to assist you with your individual problems. For all the facts, write for your copy of Bulletin No. 48-41. Chain Belt Company, 1609 West Bruce Street, Milwaukee 4, Wis.



Rex Grit Equipment

Rex Conveyor Sludge Collectors



Rex Verti-Flo

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CHAIN BELT REX COMPANY SANITATION EQUIPMENT

The Old Way

The New Way
to locate pipe
with the
M-SCOPE

. . . the instrument that takes every bit of guess work out of locating buried pipe, valves, boxes, service stubs, etc. Write for bulletin No. 6.

JOSEPH G. POLLARD CO., Inc.
PIPE LINE EQUIPMENT
New Hyde Park, N. Y.

(*Continued from page 38*)

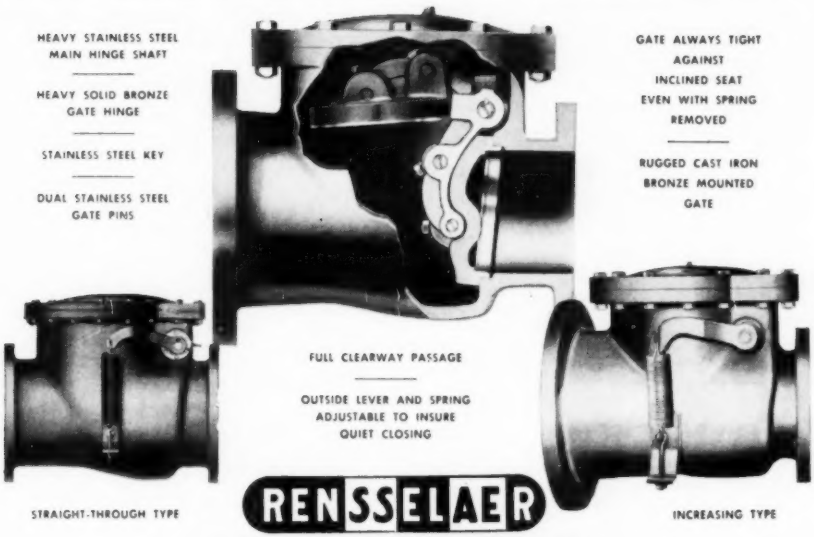
requires high-power oil-immersion lenses for identification. Furthermore, I should point out that *Anabaena*, one of the blue-green algae, is free-floating, collects on the surface of water to form a green scum, causing the so-called "water bloom," and thus would be difficult to confuse with *Treponema pallidum*, a highly motile pathogenic bacterium, favorable conditions for the growth and multiplication of which are not present in an open body of water such as that used for domestic water supply.

Concerning the resemblance between *Anabaena* and *Spirulina*, I wish to say, first, that the photomicrograph of *Anabaena* reproduced on the JOURNAL cover failed to bring out clearly the spherical vegetative cells and heterocysts which are present in the organism. Because of the coil-like shape of *Anabaena*, its individual beads are very difficult to show in a photomicrograph. You will note, however, that the beads on the top are easily recognized since they are in focus. Under higher magnification, of course, the chain-like structure made up of spherical or elliptical cells, connected like a string of small beads, with a larger bead at intervals, is clearly shown. Although *Spirulina*, too, has a spiral twist, its coils are of the ribbon type; and in that organism there do not appear the spherical vegetative cells and heterocysts present in the bead-like *Anabaena*.

The difference between these two algae may be seen clearly by comparison of the sketches of *Spirulina* on page 78 of Gilbert M. Smith's *The Fresh Water Algae of the United States* with the excellent photomicrographs of *Anabaena* by Paul P. Merkel and Edna Campbell Barker in the April 1947 and August 1948 issues of the *Taste and Odor Control Journal*. It will be noted that the photos of *Anabaena flos-aquae* by both Merkel and Barker are very similar to the photo which appeared on the August JOUR-

(*Continued on page 42*)

Seat without SLAM and seat TIGHT!


HEAVY STAINLESS STEEL MAIN HINGE SHAFT
HEAVY SOLID BRONZE GATE HINGE
STAINLESS STEEL KEY
DUAL STAINLESS STEEL GATE PINS
GATE ALWAYS TIGHT AGAINST INCLINED SEAT EVEN WITH SPRING REMOVED
RUGGED CAST IRON BRONZE MOUNTED GATE
FULL CLEARWAY PASSAGE
OUTSIDE LEVER AND SPRING ADJUSTABLE TO INSURE QUIET CLOSING
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Atlanta, Bala-Cynwyd, Pa., Chicago, Denver, Haverhill, Mass., Hornell, N. Y., Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle, Waco

(Continued from page 40)

NAL cover. As shown in the reproduction herewith, Merkel's 1947 photo was more successful in bringing out the heterocysts, although the individual cells are consequently less distinguishable.

It is of course quite difficult to recognize the identifying characteristics of various microscopic organisms from a reproduction of a photomicrograph, particularly when the organism pictured is coil-like in shape as in the case of *Anabaena flos-aquae*.

GEORGE J. TURRE

San. Engr., Board of Water Comrs.
Denver, Colo.; Sept. 6, 1949

In thanking Messrs. Riddick and Rossum for bringing the matter up and Mr. Turre for clearing it up, we'll admit to a fleeting thought or two of photogenicide.—ED.

The Noes in Front

To the Editor:

Cover pix? Count me nix! Enlarge type for volume and page numbers, month and year on backbone for easier reference and you've turned the trix to make a fine mag even better.

M. T. (HANK) BRAMMAN

National Cast Iron Pipe Div.
Los Angeles, Calif.; Aug. 22, 1949

To the Editor:

Here is my vote to discontinue the "picture cover" on the Association JOURNAL. I consider the JOURNAL a handy reference on current water works affairs, which becomes less handy when the table of contents is hidden several pages deep.

CARL B. JOHNSTON

Taylor & Taylor, Engineers
Los Angeles 14, Calif.; Aug. 22, 1949

To the Editor:

I agree with Mr. Aldrich and Mr. Weir in their preference for having the contents for the JOURNAL printed on the front cover. . . . I would also like to see you return to your old policy of printing abstracts. I can see no good reason for calling them "Condensations," instead of "Abstracts," and I do not like the idea of having them included in the advertising where it will be inconvenient to bind the JOURNALS without retaining the advertising material.

J. R. ROSSUM

San. Engr., California Water Service Co.
San Jose, Calif.; Aug. 22, 1949

To the Editor:

Since you seem to be in a quandary about your front cover, let me add my vote to those of Mr. Aldrich and Mr. Weir, thus making this a majority. . . .

Incidentally, I think the recipe for "Fingerlings" [August P & R p. 8] is only equalled by the ancient directions for preparing "Planked Carp."

JOHN F. SKINNER

1610 Idlewood Rd.
Glendale 2, Calif.; Aug. 23, 1949

To the Editor:

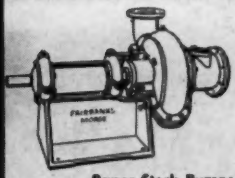
Would like to see the contents printed on the cover. Many times I have found an article easily when I did not have benefit of the index to guide me. A picture is nice but not needed to "sell" the magazine in our case. (We take it and like it!!)

Perhaps the contents could be worked in two columns near the top and the major lower portion given to a picture.

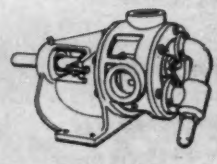
ROBERT L. HECK

Supt., Municipal Filtration Plant
Pittsburg, Calif.; Aug. 29, 1949

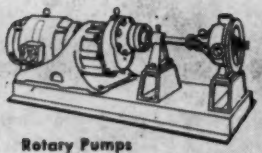
(Continued on page 44)



Paper Stock Pumps



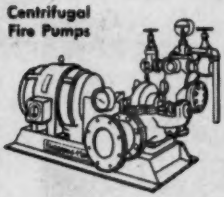
Frame Constructed Rotary Pumps

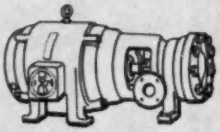


Rotary Pumps with Geared Head Motor Drive

Vertical Propeller Pumps

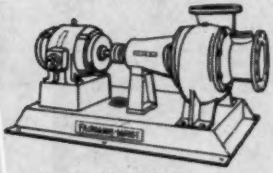
Centrifugal Fire Pumps





Two-Stage Builtogether Pumps

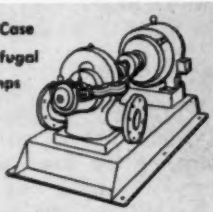
Horizontal Sewage and Trash Pumps

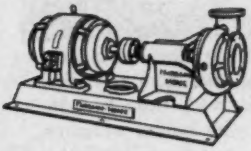


Horizontal Angle Flow Pumps

Vertical Close-Coupled Sewage and Trash Pumps

Split-Case Centrifugal Pumps

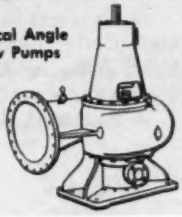




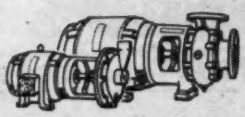
Base-Mounted Centrifugal Pumps

Vertical Sewage and Trash Pumps

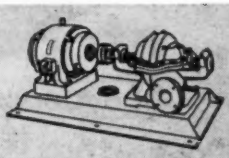
Vertical Angle Flow Pumps



Deep Well Turbine Pumps



Builtogether Centrifugal Pumps



Two-Stage Centrifugal Pumps

for Pumps...

THAT DELIVER

plus performance
lasting dependability
unsurpassed economy

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DIESEL LOCOMOTIVES • DIESEL ENGINES • PUMPS • SCALES
MOTORS • GENERATORS • STOKERS • RAILROAD MOTOR CARS
and STANDPIPES • FARM EQUIPMENT • MAGNETOS

(Continued from page 42)

To the Editor:

May I cast my "vote" for the contents on the cover of the JOURNAL. My own reaction is that the JOURNAL needs no sales appeal in the form of cover pictures, but fellows like me do need that list of contents for the frequent references we make to the JOURNAL in between indexes.

MARTIN E. FLENTJE

Research Engr.
Glen Ridge, N.J.; Sept. 2, 1949

To the Editor:

I would like to cast my vote for continuing the cover picture for the JOURNAL. I think that a picture adds to the looks of the JOURNAL. Who knows? Maybe you will print a picture of our new water plant now under construction, to be finished about the first of the year.

MAX D. SAUNDERS

Univ. of North Carolina
Chapel Hill, N.C.; Aug. 18, 1949

To the Editor:

Thanks for the microorganisms cover by George Turre. The cover made a contact in my sleepy head and I have asked Turre for microphotos of some organisms common to Denver and Salt Lake City to use in illustrating just what, for example, *Anabaena* looks like. . . .

Here, then, is one vote for continued cover pictures and my order for 20 extra copies of the August cover.

E. L. FILBY

Black & Veatch, Cons. Engrs.
Kansas City 2, Mo.; Aug. 26, 1949

Picover lovers to your ball points; the score's 9 to 5 against you, and this is the beginning of the ninth—month if not inning.—ED.

To the Editor:

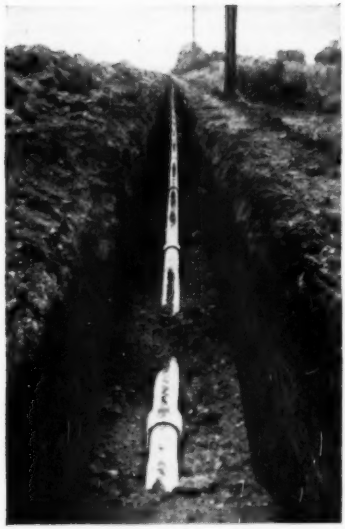
Regarding the present controversy—pictures or table of contents on the cover—I am neutral. I do, however, enjoy the pictures and find it no considerable inconvenience to have to turn a few pages to find the table of contents, as do readers Riley and Aldrich.

My suggestion for changing the JOURNAL would be to place all advertising on pages in one section so that they could be removed, thus keeping down the size of the bound volumes. You will probably not agree with this suggestion because when reading material is spaced in with advertising, the reader has to turn all the pages to read all the departments of the JOURNAL, and in so doing will note some ads which he otherwise might not see.

WILLIAM H. LANG

San. Engr.
Esso Engineering Dept.
Standard Oil Development Co.
Crawford, N.J.; Aug. 19, 1949

K&M "Century" ASBESTOS-CEMENT PIPE



No corrosion
No tuberculation
No electrolysis
No flow reduction

The "infections" that deteriorate the strength and capacity of water mains are just simply ruled out by the basic composition of K&M "Century" Asbestos-Cement Pipe. The limits of durability are extended indefinitely, yet this pipe is relatively light in weight.

Cost shrinkage begins with low shipping weight. Laying is done with low-cost equipment. Labor cost falls because this pipe is so easily placed, with any needed cutting and tapping done at the site. Time cost per joint is low and results are safeguarded by "Century" flexible couplings, with their ample latitude for radius and gradient.

Here are joints and pipe that make a line highly resistant to traffic vibration, earth settlement, and Time. Age merely strengthens K&M "Century" Pipe. Flow area and the friction factor don't change. Therefore continued pumping economy in the line is as certain as the economy of the whole K&M pipe installation. That is why men who bring this pipe to a community can take pride in their recommendation. For full information, write us.

Nature made Asbestos...
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K&M best in asbestos

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Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issued dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (Great Britain).*

PUMPS AND PUMPING PLANTS

Design, Construction and Testing of Water Works Pumps. H. ULMANN. Wtr. & Sew. (Can.) **86**:7:21; **86**:8:24; **87**:1:24 (July, Aug. 48; Jan. '49). Hydraulic laboratory of Dominion Eng. Works, Ltd., which permits almost unlimited combination of test setups, described. Water flows from main storage tank of 20,000-gal. capac. to airtight suction tank in which partial vacuum corresponding to any desired suction lift can be created by throttling intake sluice gates, thence through pump being tested, Venturi meter, weir flume and back to storage tank. Test models with impellers of 12–20″ diam. used. Tests include capac., head, efficiency and cavitation. Relation between specific speed and efficiency shown on graph plotted from actual tests. Maximum efficiency of 90% occurs at specific speed of about 135 and over 89% has been obtained with specific speeds from 90 to 195. Abrupt drop in efficiency in lower range of specific speeds. Installations made in Ottawa and Peterborough, Ont., described. In '37, 2 motor-driven centrifugal pumps of 9400 U.S. gpm., 284′ head, discharging into 42″ pipeline 900′ long, installed for Yukon Consolidated Gold Corp., Dawson, Yukon Terr. Pump reversal, valve slamming and excessive pressure on power interruption prevented by equipping each unit with flywheel and tilting-disc check valves with dashpots. Surge and time reverse flow begins in these and in standard pumping units under installation conditions shown graphically. Beginning of reverse flow retarded from 0.83 sec. for standard unit to 2.42 sec., permitting smooth valve closure and relatively small pressure rise of 48′, compared with 108′ in standard installation. All theoretical treatments of centrifugal pump design involve certain suppositions to bridge gaps between theory and fact. Laws of similitude, however, permit prediction of performance of any size pump operating at any speed if performance known for similar unit having water passages of exactly same dimensional proportions. Application of these laws in pump design outlined and results attainable illustrated by data on units at Toronto R. C. Harris plant. Station contains 11 pumps ranging in capac. from 5 to 50 mgd. (Imp.), all carefully tested before acceptance, and hence results truly comparable with lab. model tests. There are 4 raw-water, 3 wash water and 4 filtered-water pumps, latter consisting of 2 single-stage pumps in series and coupled together for single-motor drive from one end. Head per stage varies from 54′ to 135′ and specific speeds range from 73.2 to 187.1. All are horizontal-shaft, vertical-suction, vertical-discharge, double-suction units directly connected to motors operating on 2300-v, 3-phase, 25-cycle current. Induction motors used for wash water pumps and synchronous motors for others. Largest of cast-bronze impellers over 3′ diam. Each unit specially designed on basis

(Continued on page 48)

40 Years of Protection

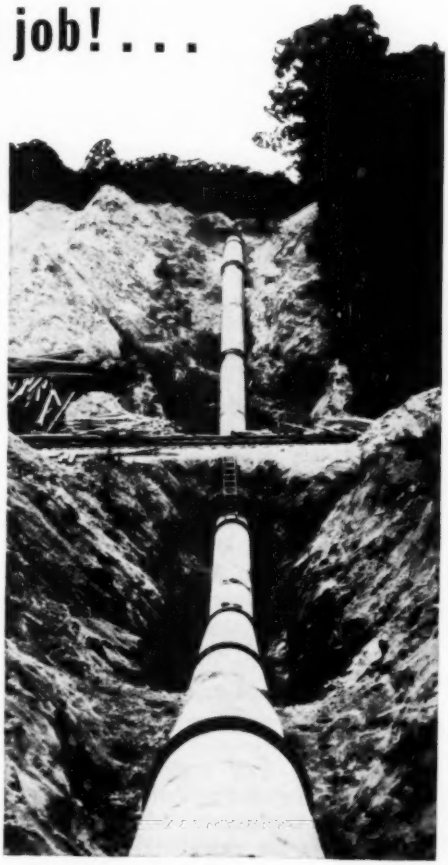
earned Koppers Bitumastic this job! . . .

In 1948—when the city of Springfield, Mass., met increasing demands for water with 26,000 feet of new 48-inch line — Koppers Bitumastic® 70-B Enamel was specified as an interior and exterior protective coating. With good reason, too, for Springfield engineers had first-hand knowledge of the long-lasting protection of Koppers Bitumastic.

In 1909, when Springfield's Westfield Little River System was started, seven miles of 42-inch line were coated with Koppers Bitumastic. For 40 years, the Bitumastic Coating has kept flow capacity high and guarded the line against corrosion. Other lines, laid in 1929 and 1943, also are protected by Bitumastic.

Inside the pipe, the glass-smooth, high-gloss surface of Koppers Bitumastic Enamel forms a barrier against tuberculation, rust and corrosion. Bitumastic keeps water from touching the underlying steel pipe surfaces . . . protects against the corrosive action of soil chemicals . . . has high electrical resistance. And it won't deteriorate with age.

If you're planning a water or sewage line, turn the coating job over to engineers of Koppers Contract Department. They'll handle it from start to finish, assuring long-lasting protection for the project. Write for complete information on Koppers Contract Service.



Springfield's new 48-inch line is shown crossing beneath railroad tracks through 72-inch pipe placed in an open cut. The new steel line, like others in the Springfield system, is protected with Koppers Bitumastic Enamel.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC., Dept. 1014T Pittsburgh 19, Pa.

(*Continued from page 46*)

of model tests to give highest efficiency at desired capac. and normal head, conditions of purchase including provision for reductions in price for efficiencies below those guaranteed. Reductions, based on anticipated values of pump efficiency variations, ranged from $650 to $4450 per 1% efficiency for raw- and filtered-water units and $280 to $350 for wash water pumps. Great care observed in detg. efficiencies, including use of calibrated instruments and photographic recording of instrument and gage readings. Guaranteed overall efficiencies exceeded by 0.9–3.3%. General data for each unit tabulated and performance of raw-water pumps depicted graphically and compared with model tests. R. C. Harris Pumping and Purif. Plant, Toronto, includes 4 raw-, 4 filtered- and 3 wash water pumps. Two largest filtered-water units, 25-mgd. capac. and 270′ head, are 2 single-stage, double-suction pumps piped in series and coupled for single-motor drive from one end. Max. permissible speed for 25-cycle power was 750 rpm. Particular attention paid to design of U-shaped interstage connection below floor level to prevent whirl induced in standard elbows and bends. Design of elbows, based on experience with elbow draft tubes in hydraulic turbines, checked by model tests. Overall efficiency 88.4 and 88.6%, compared with 86.0% guaranteed. Only unit which did not meet guarantee in first form was 50-mgd. raw-water pump. Noise indicated coming and going whirl in suction passages. Exact model showed similar low efficiency and noise. Suction nozzle had been made relatively shorter than indicated in original model and this departure from model design led to considerable variation in performance. New lower-half casing of design homologous to original model gave overall efficiency of 88.4%. Experience confirms value of model testing. Large-capac. centrifugal pumps must be fabricated individually. Problems involved in interpretation of model test data in arriving at satisfactory design discussed.—*R. E. Thompson.*

Control of Cavitation Effects in Water Works Pumps. H. Ulmann. Wtr. & Sew. (Can.) **87**:3:15 (Mar. '49). When water flows through zone where absolute pressure below vapor pressure of water at operating temp., small, vapor-filled cavities form and grow. When higher-pressure zone reached, vapor condenses and cavities collapse with great rapidity. Impact of molecules upon one another so great that rebound causes cavities to re-form and again collapse. When collapse occurs near wall, molecules bombard wall with such intensity that pitting eventually results, and, as pits create favorable conditions for cavitation, condition self-accelerating. Certain stainless steels very resistant to cavitation. Admittance of air at strategic points to provide shock-absorbing cushions another means of minimizing pitting. Cavitation may be due to excessive draft head and suction lift, deviation of operating conditions from point of best performance, faulty design, rough surfaces or vibration. Design faults include incorrect blade angles, abrupt curvature, maldistribution of flow areas and unbalanced proportions of component parts. Abrupt curvature causes streamlines to part from boundary surfaces. In such instances, cavitation may occur in high-pressure zones where least expected. Excessive cavitation results in low efficiency, low power and capac. relative to model performance, and noisy operation. Ability of pump to lift water is measured by cavitation factor, σ. "Critical sigma" corresponds to suction lift at which cavitation begins, increase causing definite drop in efficiency and capac. Cavita-

(*Continued on page 50*)

THE SUN NEVER SETS ON

% PROPORTIONEERS % Little Red Pump

%Proportioneers% Heavy Duty Midget Chem-O-Feeder — "The Little Red Pump" — is known and trusted in every corner of the world. To the Chinaman, African, and American alike it means safe, pure water. It handles the all-important jobs of water sterilization, taste and odor control, water softening, and dozens of other water treating applications. Because of its extremely simple, rugged construction, the Little Red Pump can be safely operated by almost anyone. It treats from a few gallons to a million gallons of water a day and feeds chemicals up to 7½ g.p.h. against pressures to 85 p.s.i. The chemical being fed shows plainly in the "See-Thru" plastic head and the action of the valves and diaphragm is clearly visible. Over 27,000 %Proportioneers% units right now are making this a healthier, better world to live in.

Write for Bulletin HDM-2

FEEDS . . .

Hypochlorite Solution
Hexametaphosphate
Alum Solution
Ferric Chloride
Soda Ash
Sodium Fluoride
and other water treating chemicals

% PROPORTIONEERS, INC. %

PROVIDENCE 1, R. I.

(Continued from page 48)

tion factor corresponding to design and form of pump can be ascertained by test only. Varying suction lift while maintaining pump speed const. is most economical test procedure for relatively large model pumps. Arrangement for such tests described, together with examples of tests. Must be remembered that laws of similitude not dependable for operation at sigma values less than "critical sigma." Good practice, therefore, to choose pump designs having performances within zone of safe operating sigma. One of raw-water pumps (40 mgd.) at R. C. Harris plant, Toronto, has pump efficiency of 93.5% but rumbles somewhat and requires small air admission at suction inlet for damping noise caused by slight cavitation. Some deviation in shape and form of casing and impeller may have shifted starting point of disturbance into field of higher heads. No damage has resulted and efficiency and capac. not affected. Model testing in specific speed range 60–200 has shown that, for properly designed impeller blades, number of blades has practically no influence on quality of performance.—*R. E. Thompson.*

Water Works Power Plant Practice. The Comparative Costs of Steam-, Diesel- and Electrically Operated Machinery. T. P. WAKEFORD. Wtr. & Wtr. Eng. (Gt. Br.), **52**:169 (Apr. '49). Types of duty required of water works pumping plants are: [1] pumping raw river water into reservoirs—occasional operation; [2] pumping raw river water into reservoirs—continuous operation; [3] filtration plant machinery; [4] basis-load stations—after filtration most river-derived water pumped into supply from large basis-load stations, whose costs are difficult to generalize because of wide range of load factor and power consumption; [5] repumping stations, taking water from service reservoirs and pumping it into others at still higher levels; [6] well stations; and [7] booster stations, taking water from main under pressure and forcing it into adjacent system at increased head. Types of plant available or contemplated are: [1] steam, from mechanically fired boilers in excess of 250 psi. and 650° F. (turbines driving centrifugal pumps most economical); [2] Diesel engine drive centrifugal or reciprocating pumps; [3] gas engines; [4] gas turbines not now in use for pumping; and [5] electrically driven plant. Reciprocating pump reliable and highly efficient piece of machinery but heavy first cost makes it expensive to install. Centrifugal pumps low in first cost, occupy relatively little space and reasonably efficient. In selection of suitable pumping plant, capital costs can be divided into machinery, buildings, land, fuel storage, contingencies and local tax charges. Operating costs comprise: fuel or power, lubricating oil, repairs, wages, general maint., stores, supervision, lighting and heating. Rates of fuel or power consumption used herein, except as noted, are: steam turbines driving centrifugal pumps, 10–15 lb. steam per water hp-hr.; oil engines driving centrifugal pumps, 0.5 lb. oil per water hp-hr.; oil engines driving elec. generators, 0.55 lb. oil per kwhr. Eff. of elec. motors, including transformer losses, 90%. Power factor, 0.9. Eff. of centrifugal pumps, 75%. Overall eff. of elec. pump. set, 1.1 kw. per water hp. Boiler evapn., 7.5 lb. steam per lb. coal. In raw water, occasional-pumping station lowest annual cost is that of electrically operated station at 5.54*d* per water hp-hr. If plant runs continuously, lowest annual cost is Diesel plant at 6.25*d* per water hp-hr. If favorable rates could be obtained, there is not much doubt that electrically driven plant would be installed in new station. In raw water continuous pumping, all elec. rates give

(Continued on page 52)

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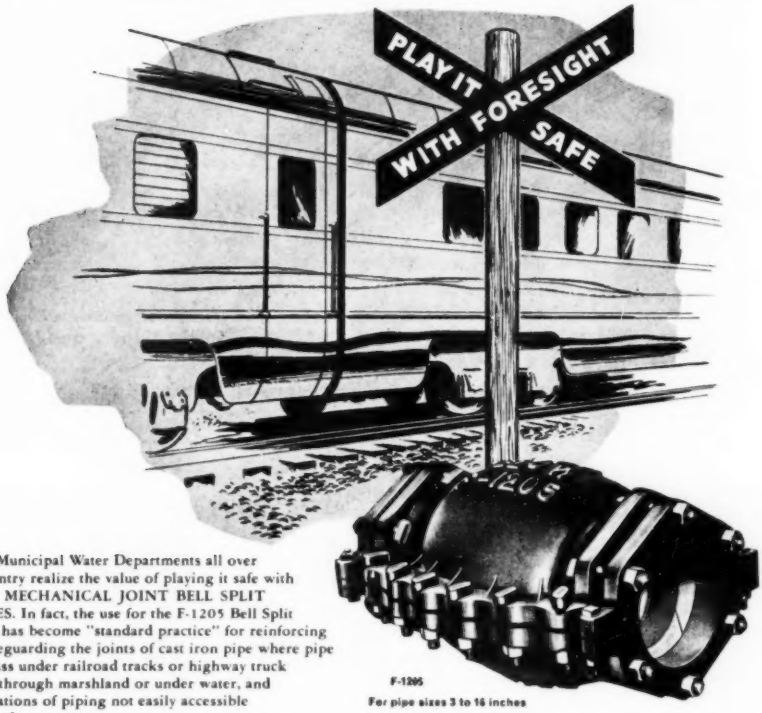

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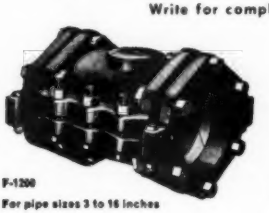

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(*Continued from page 50*)

lower costs than Diesel or steam plants. In filtration plant, lowest annual cost is 2.49*d* per water hp-hr. when reservoir pumping done by high-speed Diesel engines and filter pumps operated by purchased electricity. In repumping station, elec. scheme will give lower cost, at 1.84*d* per water hp-hr. Well station shows electricity with lowest annual charges at 1.68*d* per water hp-hr. In booster station, oil engines would not be competitive with elec. motors. Therefore, comparison lies between various (elec.) rates. Lowest annual cost is 3.22*d* per water hp-hr. In heating pumping stations electricity not competitive with coke or oil for direct heating of building. If heat pumps used, one elec. rate gives working costs lower than those for coke-fired boiler, but oil engine-driven plant incurs lowest working cost of any system. Approx. est. of power lost by rotor resistance method of motor speed control when driving centrifugal pump shows $P = T(\omega_1 - \omega_2)$ where P is rotor loss, T is torque, power of rotating field is $T\omega_1$, power of rotating output is $T\omega_2$, and ω angular speed of impeller. In all but minor pumping stations standby generating machinery must be installed. If power rate warrants, standby generators can be used for peak-lopping in winter and waste heat produced used for warming buildings. —*H. E. Babbitt.*

Submersible Pumps and Motors. W. L. GARDINER. Wtr. & Wtr. Eng. (Gt. Br.) **51**:530 (Nov. '48). Submersible motor British invention, first being patented by W. R. MacDonald in '08. Reed-Cooper designed first

(*Continued on page 54*)

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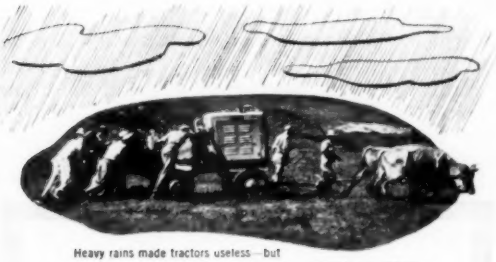

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(*Continued from page 52*)

British borehole type motor in '30. Submersible motor squirrel-cage type. Rotor revolves in water and stator conductors kept from contact with water. Water kept from windings by mech. means usually in form of thin alloy steel tube forming inner wall of stator. In "wet stator" motor windings insulated by dielectric impervious to water. Full use made of excellent cooling properties of water. Dielectrics used are rubber, synthetic rubber, polythene and polyvinyl chloride. Thermoplastic materials superior to rubber. Stator windings usually "former-wound" in dry-stator motor but are "pull-through" in wet-stator machine. Either type can be connected in star or delta. Most submersible motors have water-lubricated journal bearings. With any medium other than water, units must be supplied with fresh lubricants at definite intervals; 1500 to 6000 hr. running. Dry motor smaller than wet motor for same power, but heat dissipation difficult in dry motors, limiting them to about 70 hp. In dry motor, stator enclosure device prevents pressure equalization and limits depth at which pump may be installed. Pump part of unit follows vertical centrifugal pump practice to certain extent. Main designs bowl type, cell type and casting type. Impellers mostly of radial and mixed flow types. Former give high head per stage; latter used for moderate heads and large quants. Axial thrust of impellers cared for by fitting high-duty thrust (bearing) in motor. Materials used in bearing include pads of stainless steel, aluminum, bronze and phenolic resin. Submersible pumping units made in wide range of sizes from fractional hp. to 400 hp. In addn. to borehole types there is marine submersible salvage pump. Accessories needed for borehole installation are steel or cast-iron rising main, control gear, trailing cable, and valves. It is customary to fit gate and check valves on discharge from pump. Largest submersible pumps in use made for dewatering flooded tin mine in Malaya. Each of four units has capac. of 750 gpm. (Imp.) against lift of 1280'. Each motor develops 400 hp.—*H. E. Babbitt.*

Velocity Distribution in Roto-Dynamic Pump Casings. HERBERT ADDISON & RAMADEN SADEK. The Engr. (Gt. Br.) **186**:459, 484 (Nov. 5, 12, '48). Basic plan in all expts. to establish suitable transverse plane in or near pump outlet flange, to choose number of representative points in this plane, and at each to try to measure magnitude and direction of water veloc. Measurements made at const. pump speed and various flow rates. Instrument used pitot cylinder, adaptation of pitot tube which permits veloc. components in two directions at right angles to be closely estd. What strikes eye is helical or spin motion of water as it leaves pump. Direction of spin progressively changes as rate of discharge rises. At lowest rate whirl is counterclockwise, at highest rate of flow there is clockwise whirl. Zero whirl seems to occur at 88% discharge. Flow conditions within rotor can be deduced from study of simpler types of rotor at low rates of discharge. While water is in rotor it rotates with respect to pump shaft and corresponding tangential component is termed "whirl." Within volute, on other hand, it appears that axis of rotation of water perpendicular to pump shaft. To denote this tangential component, term "spin" used. Spin veloc. components of trivial magnitude or absent altogether. For one discharge there may be great variation in vertical veloc. components, from 0.5 m./sec. at point of traverse nearest pump shaft to nearly 6 m./sec. at most distant point. Examg. trend of veloc. distrs., surprising uniformity observed so long as

(*Continued on page 56*)

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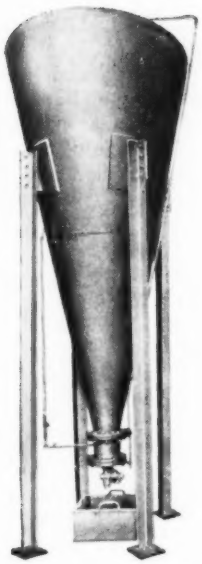

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(Continued from page 54)

pump discharge below designed value. Thereafter important variations take place. Theory that type of free vortex motion prevails would imply that inner filaments near impeller rim move faster than filaments near outermost wall of volute. If such motion existed in pump examd. it had been damped out by time stream reached lower measuring plane. Conventional method of estg. total energy received by liq. based on [1] pressure measurements at inlet and outlet flanges, [2] ests. of mean veloc. at flanges, deduced from pump discharge, and assuming that veloc. vectors uniform over whole area. What little justification there may be for this assumption is revealed by these studies. Total kinetic energy per sec. passing measuring plane can be expressed thus:

$$E_n = Qw\left[\left(\frac{Q}{A}\right)^2 \Big/ 2g\right]$$

$$E_t = \Sigma w(\Delta a)\, V \frac{U^2}{2g}$$

where Q is discharge, w is density of water, A is gross area of measuring plane, U is absolute water veloc. at point, Δa is small area in plane containing that point, V is component of U normal to plane, E_n is nominal energy and E_t is true energy. Then difference as percentage of nominal energy gain in pump is $\frac{100(E_t - E_n)}{He}$.

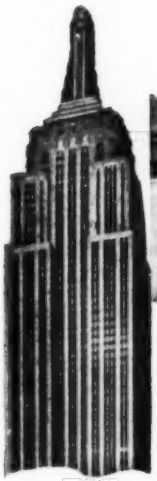
In screw pump at 31% flow, energy excess is 4%; in centrifugal pump at 140% flow, energy excess is 33%. Does this imply that pump gross efficiencies can be augmented by equiv. amts? In general it would seem that question of energy recovery of moment only when pump discharge much below or above designed discharge.—*H. E. Babbitt.*

Axial-Flow and Propeller Pumps for Water and Sewage. H. Ulmann. Wtr. & Sew. (Can.), **87**:4:25 (Apr. '49). Propeller type pumps suitable for large quants. at low heads—up to 35′—without unduly low setting. Whirl conditions at inlet to impeller reduce capac. and eff. and may cause cavitation, hence design of suction well important. Means of preventing whirl outlined. In contrast to centrifugal pumps, power input highest at shutoff (200–300% of that at best eff.) and decreases with increasing discharge and decreasing head. Therefore should never be operated against shutoff pressure. Siphon arrangement for discharge pipe dispenses with gate and check valves and provides soln. for water hammer problem. Opening of air inlet valve at top of siphon upon stopping pump breaks vacuum and prevents reverse flow which otherwise occurs quickly. In '35, 3 units installed at Montreal filter plant, each of 50-mgd. capac., and designed to operate under 18.5′ head and at 400 rpm. Guaranteed eff. of 77% exceeded by 3%. No cavitation or wear and spare impeller never used. Similar pumps being installed at Toronto's new sewage disposal plant. Also used for condenser cooling water, drydocks and power plants.—*R. E. Thompson.*

Effect of Setting on Performance of Centrifugal and Propeller Pumps. Robert W. Angus. Wtr. & Sew. (Can.), **87**:7:27 (July '49). Much greater care must be exercised in low-than in high-head installations to keep plant losses to min. Similar head losses in valves and so forth represent much greater percentage loss in former, and danger of rupture due to water hammer pressure greater as pressure rise much higher percentage of normal. Example described with illustrations and diagrams of installation in which capac. was 93.8% and power consumption 106% of rated quants., whereas improved setting would have permitted 104.8% of rated capac. with 95% of rated power, and reduction in

(Continued on page 58)

Many are the reasons why Smith hydrants are used by America's leading cities!



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5. Compression-type valve.
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(*Continued from page 56*)

power consumption per unit vol. from 112 to 91% of rated consumption. Water hammer pressure due to sudden closure of foot valve on suction side—only device acting as check valve in installation—resulted in cracking of casings in 2 of 3 pumps. "Sudden closure" defined, and emphasized that magnitude of water hammer pressure is mainly function of rapidity with which veloc. in pipe reduced and has little to do with length of pipe involved. —*R. E. Thompson.*

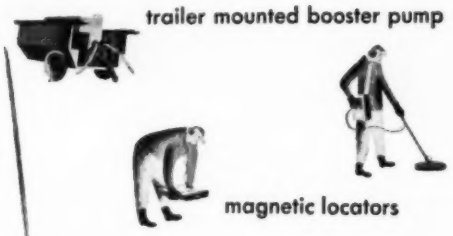
BACTERIOLOGY

The Survival of Pathogenic Intestinal Bacteria in Well Water. D. Bartos, J. Bánsági & K. Bakos. Z. Hyg. Infektionskrankh. (Ger.), **127**: 3/4:347 (June 20, '47). Small, shallow, cement-lined wells sunk in sandy gravel soil and infected with large numbers of organisms of enteric and dysentery groups. No evidence of multiplication found and number of organisms fell rapidly. Cultures made from mud at bottom of wells remained positive for periods up to 45 days from date of infection. These cultures proved to be more sensitive in detecting infecting agent than cultures made from pad of Seitz filter through which large vol. of water had been passed.—*B.H.*

Bacteriology of Water Samples From Water Mains. E. Windle Taylor. Proc. Soc. Applied Bact. (Gt. Br.), **1**:34 ('47). Water samples obtained from distr. system with wells as source found to be of high order of bact. purity. In contrast, river-derived supplies, after treatment including postchlorination, invariably showed contamn. when sampled from distr. systems. Chlorine-resistant aerobic spore-formers predominating organism at 37°C. incubation temp., with occasional sample being positive for coliform group. "Growths such as fungi imperfecti and actinomycetes occur and accumulate on inner surface of pipes" in large office and apartment bldgs., imparting moldy or musty odor to water. "It has become established practice to sample every repaired and disinfected main, and water in it must conform to accepted stds. of bact. and chem. qual. for mains water before it is returned to service." There were 3 possible sources of contamn. at site of repair: "(a) Disturbance of and infection by silt in main. (b) Infection from mud and water in trench." (c) Infection by jute yarn used for calking pipe joints. In only one pipe was silt found to contain coliform organisms; however, tubercles on inner lining of pipes found to contain sulfate-reducing bacteria. "On other hand, every sample of mud and water from trench found to contain coliform" organisms. Small sample of jute packing investigated from each repair job and found to be highly infected with bacteria, and coliform organisms of every type abundant. Apparent that jute packing might be source of subsequent water main contamn. Lab. examn. of tap water–soaked jute packing secured from repair operation, incubated at 4°, 10°, 16° and 22°C., showed increase in coliform count at 22°C. over period of more than 6 wks. At 16°C. and 10°C., increase much slower, and at 4°C. no multiplication of these organisms whatever. Worth noting that *Esch. coli* has never been isolated from jute packing obtained directly from store or contractors, so fecal coli probably acquired during handling on job. Fecal streptococci also recovered from raw jute. Anal. of results of tests from water samples from mains between '41 and '46 showed interesting seasonal effect in frequency of coliform types. When water temp. rises above 10°C., *Aer. aerogenes* becomes prevalent, and above 13°C. irregular types appear more frequently. Between 13°C. and 17°C. number of *Esch. coli* isolations increase. Re-

(*Continued on page 60*)

all this and radio too,



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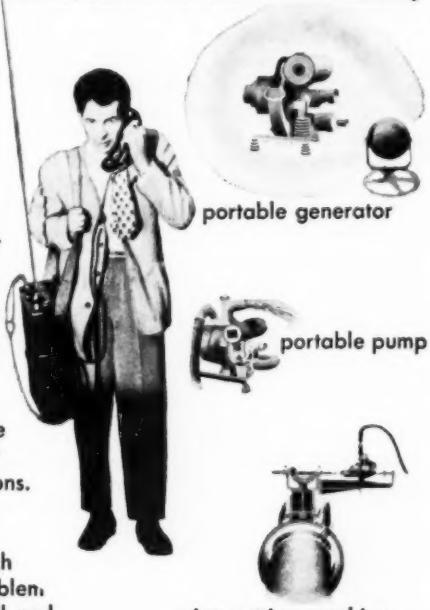

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(*Continued from page 58*)

searches have been undertaken into better methods of chlorination of mains and into methods of sterilizing and treating joint packing.—*P.H.E.A.*

A Study of Coliform Organisms in the Melbourne Water Supply and in Animal Feces, With Observations on Their Longevity in Feces and in Soil. Doris A. Bardsley. J. Hyg. (Gt. Br.), **46**:3:269 (Sept. '48). Results recorded obtained from study of coliform organisms in water supply to city of Melbourne, Australia. Three large impounding reservoirs provide storage facilities, but water receives no further treatment either by filtration or chlorination. Catchment area carefully protected from public access, but wild animals and birds contribute fecal organisms to water. Water samples examd. by methods I and IV of Wilson and both MacConkey broth and lactose broth used as primary media. Only 1.6% of MacConkey broth presumptive-positive tubes failed in confirmatory test for coliform types, while corresponding figure with lactose broth was 10.8%. Author does not consider that *Clostridium welchii* responsible for numerous unconfirmed positive results obtained in lactose broth because routine tests on potable water samples gave only 5.3% samples positive to *Cl. welchii* test and in these the organisms seldom exceeded 1 per 100 ml. of sample. [Possible, however, that *Cl. welchii* counts would have been higher in pold. water samples in which high coliform counts recorded were obtained.] Specificity of 44°C. test for *Esch. coli* type I very high under Australian conditions. From 6986 coliform strains examd., 4470 *Esch. coli* I and only 22 other strains produced gas in MacConkey broth at 44°C. Of these, 19 were Irregular II which has affinities with fecal coli and 3 were Irregular IV which has affinities with intermediate aerogenes-cloacae group (I.A.C.). Therefore production of gas at 44°C. very rare in organisms of I.A.C. type (0.04%). On other hand, investigation into specificity of citrate test for organisms of I.A.C. group gave results similar to experiences of other workers in that I.A.C. count by method IV augmented by growth of coli I and nonlactose fermenting organisms, particularly *Pseudomonas pyocyanea*. Natural habitat of coli II and Irregulars I and II still uncertain, and with regard to both coli II and Irregular I evidence accumulated from waters in Victoria does not throw any further light on their origin. Although Irregular type II only found in 8 samples, it was never associated with I.A.C.; it was present in 2 samples alone and was present along with coli I on 5 occasions. These findings suggest

(*Continued on page 62*)

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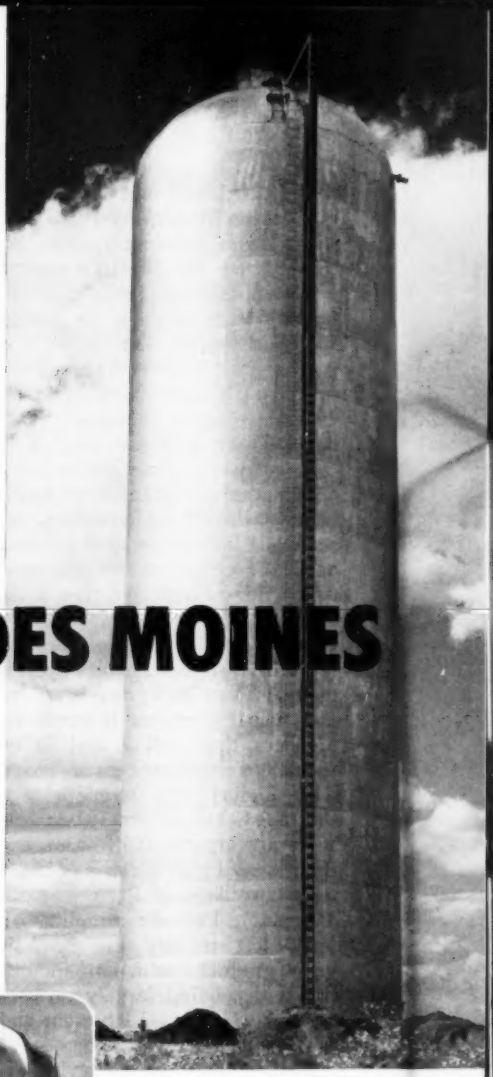

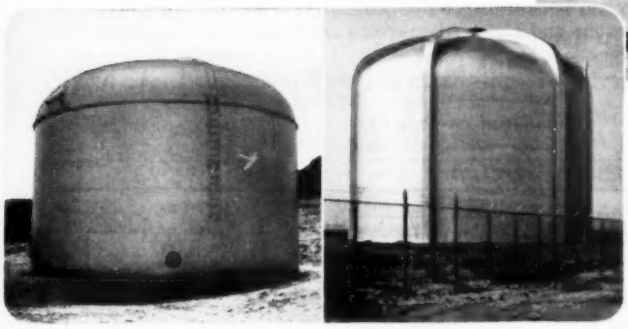

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(Continued from page 60)

that Irregular II may be of fecal origin. Ratio of *Esch. coli* I to I.A.C. in water from different sources in Victoria shows that in catchments where animals and birds plentiful, coli I dominant; after storage in reservoirs, I.A.C. dominant but by time water reaches city distr. services after passing through open channels, proportion of coli I again increases. Coliform counts very high in samples of decaying leaves, algae and other vegetable matter found in sumps and settlement basins along aqueducts and on screens. Incubation of these materials at 22°C. caused active multiplication of bacilli. *Esch. coli* type I isolated from every sample of animal feces examd. and I.A.C. organisms also identified in over half samples by Wilson's method IV. However, I.A.C. organisms usually present in much smaller numbers than coli I and in only 4 specimens were numbers approx. equal. This finding adds strength to belief that I.A.C. "organisms when found in feces are organisms of passage rather than true fecal bacteria which have their normal habitat in intestines of animals." Periodic sampling of cow dung left to dry in open showed very gradual reduction in coliform count, depending largely on moisture content. *Esch. coli* I present and predominant 3–7 wk. after specimens voided. Expts. on longevity of coliform organisms in soil showed that all types tended to die out. No evidence of I.A.C. types growing and multiplying under exptl. conditions provided. In fact, in summer expt., bacteria died out more rapidly, partly because hot weather had desiccating effect. In addn., no change in reactions of organisms observed during their long sojourn in soil. "Soil" sample collected from site of cowshed demolished 3 yr. earlier. Coliform organisms 2,500,000 in 100 g.; *Esch. coli* I isolated, and ratio of coli I: I.A.C. over 8:1 by method IV. Evident that under warm, moist conditions, coliform organisms disappear very slowly, so that washings from soil contg. accumulations of animal feces will be heavily infected with intestinal organisms long after excrement has been deposited.—*B.H.*

INSTRUMENTS AND APPARATUS

Electrical Fuse Operated by Failure of Water Supply. A. BAILEY. Chemist Analyst **38**:2:39 (June '49). Failure of lab. water supply ever-present contingency requiring positive provision to safeguard electrically heated, water-cooled lab. devices to prevent damage to apparatus, loss of sample or fire. Fig. 1 shows type of simple design and positive action. Upper tubu-

(Continued on page 64)

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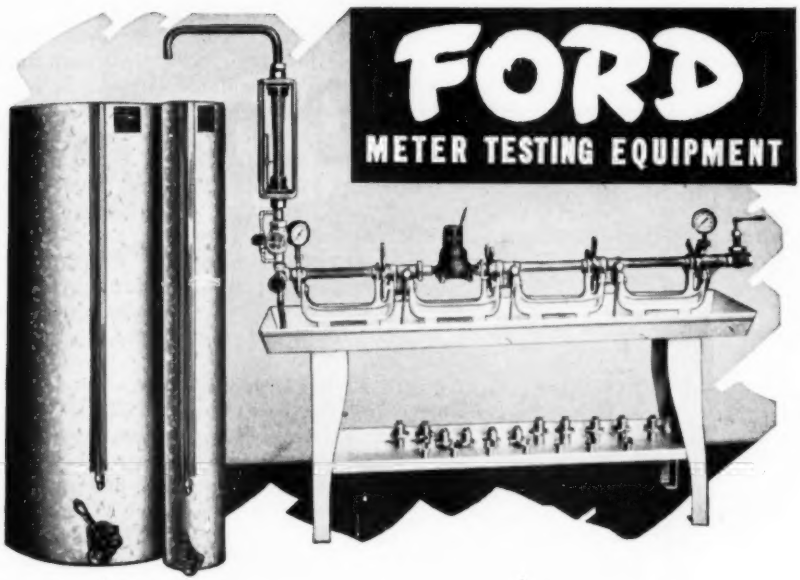

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(*Continued from page 62*)

lation of device attached to water hose in outlet half of cooling circuit, while hose draining to sink attached to lower tubulation. In normal operation, water flow sufficient to maintain level at *A*. In event of water failure, water contained in body of trap drains out through small hole *B*, exposing fuse wire *C*, which melts when cooling effect of water removed. Current-carrying capacity of fuse wire may conveniently be ¼–½ of that required for normal operation of circuit. Electrical connections to fuse wire made by machine screws through 2-hole rubber stopper as shown. Dimensions optional and only elementary glass-blowing skill required. Metal may be employed in construction at sacrifice of visibility. Numerous other variations in design possible, employing same principle, even to incorporating water fuse in integral design of such apparatus as distilling systems. It is applicable not only to stills but also to water-cooled diffusion pumps, liquid-liquid and liquid-solid extractors, reflux assemblies and most water-cooled lab. apparatus. Bimetallic strip may be substituted for fuse, to operate intermittent warning bell or light. Fuse may also be used for warning purposes with relay having contacts which close when circuit opened.—*Ed.*

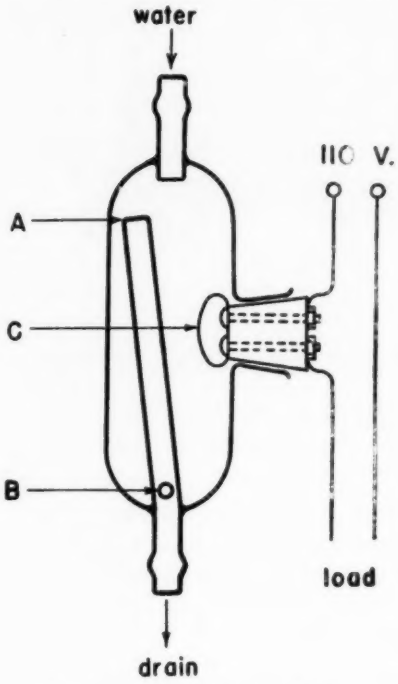


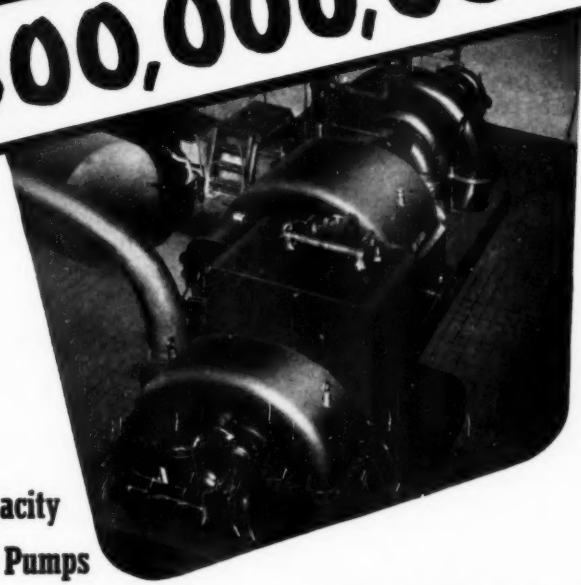
FIG. 1. Water Failure Indicator

New Solution Sampler. ANON. Can. Chem. and Process Ind. **32**:7:643 (July '48). Apparatus designed by G. F. Brandon and H. D. Jorgensen for continuously sampling free-flowing solns., described and illustrated. Device consists of inverted jar, 3″ in diam. and 6″ high, through cap of which passes entrance tube (*A*), siphon tube (*C*), sample overflow tube (*D*) and air vent tube (*E*). Liquid flows into jar continuously, level of liquid rising until siphon filled, at which point sample withdrawn and then soln. discharged until siphon breaks; this sequence repeated automatically as long as desired. Recommended diam.: *A*, 5/16″; *C*, 7/16″, flared to 1.5″ at bottom; *D*, 3/16″; *E*, 5/16″. Const. head can be maintained by overflow box. Bottom of siphon tube (*C*) must be at least 3 times diam. of tube, otherwise siphon will not break and mixt. of soln. and air will flow out. Tube *C* must be larger than *A* so that drainage rate will exceed inflow when siphon working.—*R. E. Thompson.*

Portable Water Level Recorder. ANON. Civ. Eng. (Gt. Br.) **43**:135 (Mar. '48); The Engr. (Gt. Br.) **185**: 121 (Jan. 30, '48). Instrument, designed by J. Walter, consists, in essence, of series of sealed brass tubes suspended in water from spring balance. Weight recorded on spring balance varies as water rises or falls in tubes. Mechanism records movement

(*Continued on page 66*)

1,300,000,000



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(*Continued from page 64*)

of spring balance. By altering size of tubes and spring, instrument could be constructed to record variations within any reasonable limits.—*H. E. Babbitt.*

Automatic Device for Study of Intercrystalline Cracks in Boiler Steel. N. G. PATSUKOV & A. AKOL'ZIN. Factory Lab. (U.S.S.R.), **13**:577 (May '47). Gives details of device for simulating conditions within boiler installation in which slight seepage of water through riveted joints. Apparatus permits application of constant strain to sample while regulated "leakage" of water at constant temperature takes place.—*Corr.*

CORROSION

Copper Underground: Its Resistance to Soil Corrosion. Copper Development Assn., London, C.D.A. Publication No. 40, 50 pp. ('48). Presents lab. studies and results of field tests on copper, lead, steel, and cast iron with particular reference to use of copper pipes for underground gas and water services. Includes numerous data tables. 35 references.—*Corr.*

On the Protection of Iron Parts in Contact With Sea Water by Galvanic Contact With Zinc. F. TODT. Arch. Metallkunde. (Ger.), **1**:6:288 ('47). Iron cooler tubes can be satisfactorily protected against corrosion by artificial sea water when placed in galvanic contact with zinc. Ratio of zinc to iron surface may be as low as 1:1000. Effects of (1) variations in compn. of zinc, (2) formation of surface films on zinc, (3) prevailing c.d. on zinc and (4) variations in pH of artificial sea water described. Previous investigation (Bauer and Vogel, Germany, '42) found 14 sq.cm. of zinc necessary to protect 120 sq.cm.—*Corr.*

Various Methods of Studying the Behavior of Alloys in Rapidly Flowing Sea Water. F. L. LAQUE & W. C. STEWART. Métaux & Corrosion (Fr.), **23**:274:147 (June '48). Describes 3 forms of app. in operation at Kure Beach, U.S.A., with notes on behavior of bronze and cupro-nickel (including effect of small amts. of iron on 70/30 cupro-nickel).—*Corr.*

The Effects of Inhibitors and Inorganic Matter on the Corrosion of Iron in Warm Water. W. MACHU. Archiv. Metallkunde (Ger.), **1**:267 (June '47). Effects of various inhibitors and oxidants on soly. of iron in water at 60°C. investigated. Data charted and tabulated.—*Corr.*

The Application of Electrochemical Cells to the Determination of Oxygen Dissolved in Water and to the Indication of Corrosion. F. TODT. Arch. Metallkunde (Ger.), **1**:469 (Nov.–Dec. '47). Author discusses value of current measurements in certain cells for detn. of concn. of oxygen and for measurement of corrosion rates and, therefore, for assessment of efficacy of protective coatings. No precise details but literature references.—*Corr.*

Treatment of Steam Power Plant Circulating Water. Vaccination. HENRY FOUACHE. Chaleur & Ind. (Fr.), **29**:251 ('48). Scale formation ($CaCO_3$) in circulating water systems greatly reduces heat transfer; owing to large vol. of water, treatment more difficult than with boiler feedwater; phosphates, lime or acids (vaccination) have been added to reduce scale formation. Recommended treatment addn. of H_2SO_4 or HCl, then addn. of lime. To avoid deposition of $CaCO_3$, necessary that dissocn. const. (CO_3) (Ca) be less than soly. const. for $CaCO_3$; this can be realized with pH of water at equil. pH or slightly below. Theory of this treatment discussed in

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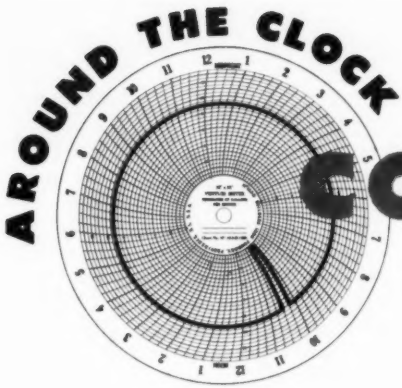
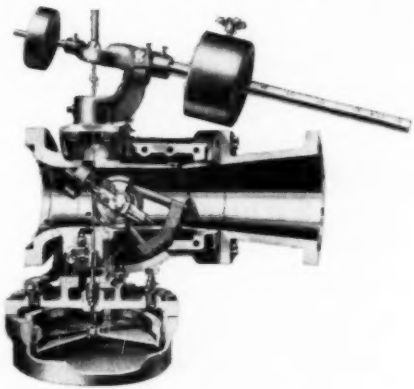


CONTROL



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(*Continued from page 66*)

detail as well as necessary control tests and graphs presented to simplify control calcns.—*C.A.*

Boiler Corrosion and Water Treatment. Admiralty Brochure (Gt.Br.) ('47). Provides descriptions (with numerous illustrations, some in color) and theoretical explanations of types of corrosion encountered in service, with suggestions for obviating or minimizing them. Also discusses scale formation; priming; chemistry of distd. water, shore waters and sea water; and chem. treatment of boiler water. Appendixes deal with circulation and heat transfer in boiler tubes, etc.—*Corr.*

Corrosion Inhibitors in Recirculating Water Systems. MARC DARRIN. Can. Chem. & Process Ind. **33**:6:512 (June '49). Inhibitors function by: [1] anodic polarization, [2] cathodic polarization, [3] forming protective coatings, [4] preventing harmful deposits, [5] removal of corrosive constituents and [6] adjusting pH. Most inhibitors function in 2 or more of 6 ways. Adjusting pH—e.g., with NaOH or Na_2CO_3—lessens but seldom elims. corrosion unless some other factor brought into action, such as deposition of protective film of $CaCO_3$. Na silicate also functions by neutralization and protective film formation. Phosphates outstanding example of prevention of harmful deposits (Type 4). One of best is Na hexametaphosphate, used effectively as threshold treatment (about 1 ppm.) in once-through systems. Metaphosphates, however, tend to lose sequestering properties on lapse of time, particularly when heated. Second method of use is to introduce much more than required to hold in soln. all metal oxides. Intermediate proportions may cause pptn. of insol. phosphates. Chlorination of water would be expected to increase corrosion but may retard it by preventing org. slimes and deposits which produce stagnant regions resulting in areas of different O concns. Removal of O with sulfite example of Type 5. Org. polar compds. believed true passivators functioning through cathodic polarization. Protection incomplete compared with anodic polarizers, but are "safe" inhibitors—i.e., insufficient dosage does not stimulate attack. Corrosion tends to be evenly distributed. Acid inhibitors, as in acid-cleaning of boilers, belong to this group and use of arsenites to inhibit HCl related. Chromate ion incapable of inhibiting HCl but effective with H_2SO_4 and H_3PO_4. Inorg. chromates and bichromates, which act as true passivators through anodic polarization, best known and most powerful inhibitors, producing self-healing protective films. In sufficient concn., effective in chloride-contg. waters. In absence of chlorides and few other deleterious elements, chromic acid completely inhibits steel and many other metals even below pH 0.5. Chloride ions act as anodic depolarizers and thus penetrate and disrupt protective oxide films. Most important is maint. of chromate concn. above min. which practice has shown effective. Best to keep pH between 7.5 and 9.5. Choice between chromate and bichromate largely cost versus convenience since identical when adjusted to same pH. Former does not require pH adjustment. Concns. commonly used for typical purposes are listed. In contrast to cathodic polarization, anodic polarization "dangerous" inasmuch as increased current flow and anodic pitting occur in areas of insufficient concn. Practically all difficulties due to failure to maintain sufficient concn. of inhibitor throughout system. Customary, therefore, to start with high concn. and gradually lower it to min. at which good inhibition obtained, without going below about 100 ppm. Results of expts. on influence of concn.

(*Continued on page 70*)

2 EASY WAYS to repair water lines

1

1.

Clean pipe.

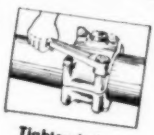
2.

Measure with Dresser tape (packed with sleeve)

3.

Fit sleeve sections on pipe.

4.



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(*Continued from page 68*)

of chromate on inhibition of corrosion of steel in NaCl solns. described and discussed.—*R. E. Thompson.*

Practical Use of Chromate Inhibitors in Engine Cooling Systems. D. D. WRIGHT. Can. Chem. Process & Ind. (Can.), **32**: 533 (June '48). Deals with control of corrosion in cooling-water system of compressors. Shows how chromate-treated steam condensate removes all danger of scale formation, removes scale already present in engine and increases expected life of piping employed.—*Corr.*

AUSTRALIAN SUPPLIES

A Comprehensive Water Supply Scheme—Western Australia. I. DAVIES. J. Inst. Engrs. (Australia) p. 1 (Jan.–Feb. '49). Author describes comprehensive scheme originally proposed for reticulating water for towns, stock and domestic purposes to certain mixed-farming (cereals and sheep) dists. of Western Australia, and for increasing supply to Eastern Goldfields areas to permit expansion of gold-mining industry. This scheme, which was beyond financial resources of state, submitted to Commonwealth government with request for aid. Government appointed committee with representatives from engineering, agricultural, economics, commerce and treasury departments to report on proposal. Committee recommended that certain sections get greater priority, which resulted in modified scheme being adopted, causing excision of over half area to be supplied and notably excluding farming areas along Great Southern Ry., but retaining provision for supply to Great Southern Ry. towns of Brookton, Pingelly, Narrogin, Wagin and Katanning. Project as originally designed was to provide increased storage in Mundaring and Wellington Res. in Darling Ranges, thus creating fundamental division into northern and southern areas, respectively. This division retained in modified scheme, principal divergence being that some southern dists. now contained in northern area. Added storage will be obtained by raising Mundaring Weir 32′, increasing its capac. from 4.65 to 15.1 bil.gal., and by raising Wellington Dam 50′, increasing its capac. from 7.5 to 38 bil.gal. Raising wall of Mundaring Weir to its ultimate economical height will meet increased demand in existing Goldfields water supply system and provide surplus water for north-eastern section of modified scheme. Further, some industries now in early stages of development completely dependent on Goldfields system for their water supply, and their expansion and continuance thus assured. Wellington Dam has as its primary function supply of water for irrigation on coastal plain, but its augmented capac. will enable addnl. areas to be irrigated. It will also provide for rural areas east of Great Southern Ry. at later stages, and have available large volumes of water for diversion to Bunbury industrial area whose development envisaged under state government's decentralization policy. Production of some hydroelec. power contemplated at Wellington Dam. This will be fed into high-tension transmission mains of southwest power scheme, which is being developed simultaneously by constr. of new power station at Collie, high-tension transmission mains from which will serve elec. pumping stations, on 30″ diam. and smaller mains, from Wellington Dam to Great Southern towns and provide power as far south as Albany for rural development now being undertaken. Author lists as necessary for full development of northern section of scheme reorganization and enlargement of both Goldfields main conduit and relevant pumping equip. Provision will also be made for auxiliary

(*Continued on page 72*)

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(*Continued from page 70*)

pumping stations, rising mains, reservoirs and distr. systems to convey water from main conduit to farms and towns. Total farming area to be served is 6,621,000 acres, together with 20 towns having total pop. of 18,250, requiring total annual quant. of 3,529,475,000 gal. to be drawn from Mundaring Weir. Under modified proposal, annual draw assessed at 3.073 bil.gal., but ultimate expansion to original conception still contemplated. Broad outline of southern section of scheme indicates 30″ main pipeline and pumping stations between Wellington Dam and existing Narrogin storage reservoir. Distr. works provide for rising mains to service tanks north and east of Narrogin, while south-running gravity main reaches nearly to Katanning, where further pumping station delivers to service tanks in vicinity. Total farming area here reached is 4,986,000 acres, and with 15 towns having total pop. of 12,050, annual draw required from Wellington Dam is 1,416,860,000 gal. In early stages sufficient water available from existing storage to meet needs of Great Southern towns, assessed for purposes of modified scheme as 306 mil.gal. annually. For farms, design for total quant. to be supplied based on unit farm of 1,000 acres, carrying wheat crop, 300 sheep, 10 cattle and farmer and his family. Avg. daily quant. allowed differs under summer and winter conditions:

Consumer	Summer	Winter
	gpa.	
300 sheep	300	0
10 cattle	100	100
Domestic needs	300	300
Total	700	400

This indicates total annual quant. of 200,000 gal. per 1,000-acre unit. Performance of existing agricultural reticulation systems suggested that max. rate of supply to be anticipated was 900 gpd., and distr. pipeline diams. calcd. on this basis. In towns, consumption records similarly showed that avg. quant. of 40 gpd. per head with max. rate of 60 gpd. per head should be allowed. However, additional allowance made for increases in pop. expected to follow provision of reliable water supply. Metered services to farms to be provided at boundary of every holding, which will be rated on acreage basis, while for towns rating will be on rental valuation basis. Revenue from modified scheme will, it is estd., meet pumping and operating costs, and major part of interest and sinking fund charges. State and Commonwealth stand to gain from increased productivity and improved standard of living in rural areas and towns affected.—*Ed.*

Two Schemes for Adelaide's Water Supply. ANON. Commonwealth Engr. (Australia), **36**:258 (Jan. 1, '49). Two large engineering projects just approved by South Australian Parliamentary Standing Committee on Public Works to provide much needed addnl. water for Adelaide metropolitan area. One project is constr. of aboveground pipeline from Murray R. at Mannum to Adelaide, and other is provision of reservoir on South Para River in Barossa dist. Each of these schemes described briefly.—*P.H.E.A.*

Planned Water Conservation in New South Wales. H. BOWDEN FLETCHER. Wtr. & Wtr. Eng. (Gt. Br.), **52**:60 (Feb. '49). Master plan aims at min. expenditure of £2,000,000 annually on constr. of dams, weirs and river protective works for 15-yr. period. Scheme includes 18 dams and 8 diversion weirs in addn. to 30–40 weirs on Barwon and Darling rivers. Major dams (and reservoirs) will be: Keepit, being constructed on Naomi river, capac. 345,000 acre-ft.; Burrendong,

(*Continued on page 74*)

A section of 78″ Lock Joint Concrete Cylinder Pipe being installed in Unit 1 of the Coachella Valley Distribution System, a U. S. Bureau of Reclamation Project, comprising some 37,000′ of 78″ and 84″ Lock Joint Concrete Pressure Pipe.

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(*Continued from page 72*)

capac. 520,000 acre-ft.; and Glenbawn, capac. 120,000 acre-ft.—*H. E. Babbitt.*

STERILIZATION

The Use of Ozone in the Purification of Water. M. T. B. WHITSON. J. Roy. San. Inst. (Gt. Br.), **68**:448 (Sept. '48). Brief history of 50 yr. of ozonation in England, France and America given. In Britain, 1896–1914, there were 15 publications on ozone in transactions of Institution of Civ. Engrs. War impeded further development. In 1919–39 chlorine in ascendancy and continued to grow in favor. Difficulties developed by use of chlorine, such as taste and odor, encouraged search for more desirable disinfectant. In 1936–37 number of ozone plants installed in country. Total capac. now using ozone is 10 mgd. In France development of ozone for sterilization of water has been more steady. Pilot plants in Nice in 1904 and Paris in 1906 encouraged installation of ozone plants in many towns, and its use as sterilizing agent has met with great favor. In America history of ozone parallels that of England. From various authorities and cities comes word that ozone has some very desirable quals. which make it superior to chlorine as bactericide and for removing odor, taste and color. In comparing use of chlorine and ozone, pointed out that under normal conditions ozone treatment more costly. Chlorine applied more easily. Residual bact. killing power possible with chlorine and not with ozone, although long experience at Ashton, England, shows no deterioration in bact. qual. over long period with ozone. Author points out

(*Continued on page 76*)

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(*Continued from page 74*)

great need for more research on ozone application to water, including conditioning of air used, current use, type of producer, etc. Four figs. given indicating equip. setups. 14 author references indicated. Several discussers add considerably to treatment of subject.—*P.H.E.A.*

Chlorination of Water Supplies. Report of Director of Water Examination, Metropolitan Water Board. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **52**:134 (Mar. '49). In 1918 Sir Alexander Houston wrote: "No taste, unless perhaps the original taste, has ever been observed after gross chlorination and dechlorination." In 1918 it had been found in Canada that addn. of ammonia before chlorination prevented tastes. In India in 1932 present director commenced investigations into relative efficiencies of chlorine and chloramine which have been continued up to present. Widely expressed belief that chloramine more powerful disinfectant than chlorine erroneous. On contrary, chlorine in free state destroys bacteria many times more rapidly than does chloramine. While free residual chlorination not applicable to board's waters, elucidation of ammonia breakpoint has provided explanation of certain anomalies in behavior of chlorine in presence of ammonia. Superchlorination has been introduced at all board's filtration works. Since such introduction, there has been marked improvement in bact. qual. of water supplied, percentage purity having increased from 96.8 to 99.8. So successful did superchlorination prove that discontinuance of prechlorination of water justified. Extreme cold retards action of chlorine and it may be that results will not be so good when such conditions prevail. Increasing speed with which superchlorination destroys bacteria permits reduction in size of contact tanks to ½ that previously required. Seems unlikely that any addnl. improvement which might be effected would be sufficient to justify capital expenditure required for pretreatment basins. Saving in cost of chems. has been at rate of £17,888 per year.—*H. E. Babbitt.*

Breakpoint. J. S. DUNN. Wtr. & Wtr. Eng. (Gt. Br.), **52**:66 (Feb. '49). Smith and Lordly (Water Works & Sewerage **88**:82) defined breakpoint as "that amount of chlorine which satisfies chlorine demand of water." This correct, although chlorine demand of water can vary with time allowed to elapse between adding dose and estg. amt. of chlorine left. Commonly accepted period of contact is 2 hr. Palin defined breakpoint as minimal point in curve in which amt. of chlorine after specified time is plotted against original dose. Type of hump-and-dip curve obtained because of reaction which takes place between added chlorine and ammonia already present in water to form chloramines. In part of curve between hump and breakpoint, conditions unstable. Need test to tell which compd., either free chlorine or chloramine, is present, as it would appear impossible to have them present at same time. Must have test which will tell when breakpoint has been reached, as it is impossible to plot series of graphs every time chlorine dose altered. In practice, chlorine and chloramine do exist at same time. First reaction between chlorine and ammonia to form chloramine is rapid; but second reaction between chlorine and chloramine, resulting in mutual destruction, takes matter of hours. Ideal-curve conditions seldom obtained because of presence of complex albuminoid ammonia compds. Should be obvious that, unless great care exercised in dosing with both chlorine and ammonia, untoward results likely to arise, and water may be dechlorinated. Deliberate dechlorination of water can be achieved by addition of ammonia sub-

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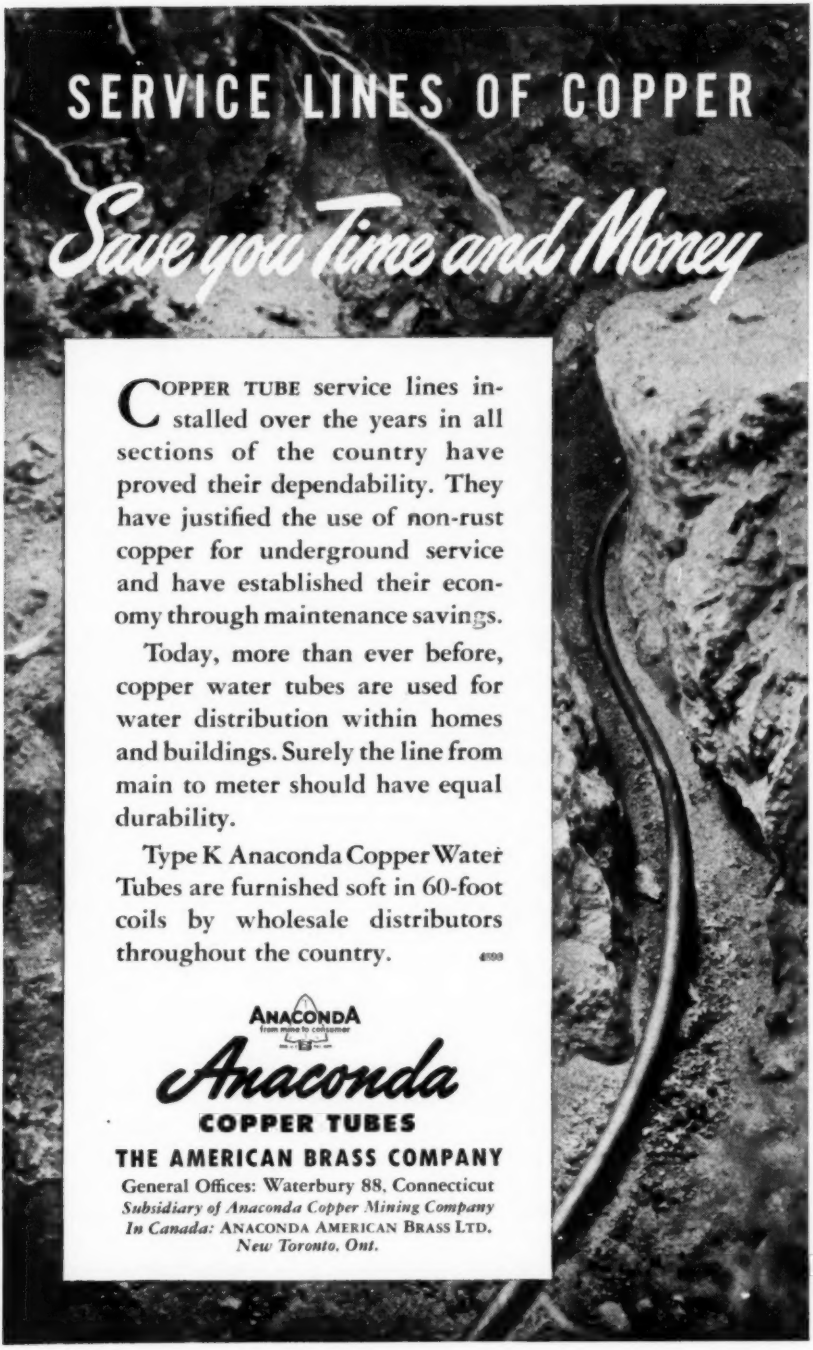
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sequent to chlorine dose. Now apparent that original definition of breakpoint as "that amount of chlorine which satisfies chlorine demand" is correct. Apparent also that no breakpoint can be obtained unless some ammonia or related compds. present to begin with. Question now arises: what tests available for routine use which will show when breakpoint has been reached? In doing test, impossible to wait until all chloramine oxidized and only free chlorine remains. One suggested compromise is to take breakpoint as point at which chloramine and chlorine present in equal amts. Most familiar test for chlorine is that using acid soln. of *o*-tolidine. With free chlorine, yellow color produced immediately, whereas with chloramine color develops slowly over 5–15 min. Two chief defects of test are acidity necessarily added to sample and standardizing of reading times. Another test for breakpoint uses methyl orange. Slightly acid solution of M.O. rendered colorless by free chlorine but not by chloramine. If breakpoint reached, color of indicator fades and rate of fading proportional to amt. of residual chlorine present. Reagent *p*-aminodimethylaniline [**I**] suggested for distinguishing between free chlorine and chloramine. It is excellent test, very sensitive and more complicated than foregoing. Colors given with **I** and chlorine are said to range from pink to red through blue and indigo to green and brown, according to amt. of chlorine present. Advantages of chloramine process: chloramines more stable than dil. solns. of chlorine alone and retain germicidal power for longer periods, especially in hot climates; chloramines not wasted in oxidizing org. impurities, as is chlorine; bactericidal power of chloramine 3–6 times that of chlorine; chloramines give no taste with phenols; chloramines best known defense against larvae or eggs of human parasites, and this method of sterilization has particular advantages in tropical climates. One of disadvantages is that if chloramine is to be stable, there must be excess of ammonia present, which can later provide nutriment for bacteria in distr. system. One claim for breakpoint is its ability to remove bacteria and elim. all gas-producing organisms; after breakpoint little bact. life remains and little aftergrowth can take place, as all org. matter that might provide nutriment is removed.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Inactivation of Partially Purified Poliomyelitis Virus in Water by Chlorination—III. Experiments With Natural Waters. Serge G. Lensen, Morris Rhian, Max R. Stebbins, Robert C. Backus & Carl E. Peterson. Am. J. Pub. Health, **39**:9:1120 (Sept. '49).

Low Temperature Increases Sediment Transportation in Colorado River. E. W. Lane, E. J. Carlson & O. S. Hanson. Civ. Eng., **19**:9:45 (Sept. '49).

Precipitation-Evaporation Relationship for the Canadian Prairie. P. C. Perry. Eng. Jour. (Can.), **32**:8:468 (Aug. '49).

Formulas Facilitate Design of Ring-Girder-Supported Pipes. H. Alden Foster. Civ. Eng., **19**:9:55 (Sept. '49).

The Chemistry of Water Treatment. V. Some Unusual Water Treatment Problems. A. P. Black. Wtr. & Sew. Wks., **96**:325 (Sept. '49).

New Tulsa-Spavinaw Water Line Uses 48½ Miles of CONCRETE PIPE

THE NEW Tulsa-Spavinaw water line, extending northeast from Tulsa to Spavinaw Creek, will use 48½ miles of 72-in. and 66-in. concrete pipe. It will be capable of delivering 40 mgd.

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Supplementing the Builders line of volumetric chlorinizers is a new gravimetric feeder especially adapted to high rate metering of chlorine gas, although accuracy at low rates is also claimed. The chlorine control cabinet and chlorine weight scale of the Model CGS Gravimetric Chlorinizer are separate, self-contained units, connected only by small air piping. No chlorine is present at the control station. Description, photography, and flow diagram in Bul. 840–F3T, available from Builders-Providence, Inc., Providence 1, R. I.

Steel shelving assembled without tools by means of a special iron-grip stud is described in a new 24-page catalog available from Equipto, a division of Aurora Equipment Co., Aurora, Ill. The stud slips into a hole in the shelf and a keyhole in the upright. A downward pressure locks it into place. Shelves are adjustable in 1½-in. steps; dividers, in 1-in. steps. Open and closed shelving, parts bins and counters are available.

"Liquid Chlorine," the second edition of the Solvay Sales Div. information bulletin, has just been issued. The booklet contains 60 pages—an increase of 10 over the 1943 edition—of the latest information on the properties of chlorine, chlorine containers, equipment and safe handling. The procedure to follow if leaks or accidents should occur is outlined in a special supplement. Requests for copies of Bul. No. 7 should be sent to Solvay Sales Div., Allied Chemical & Dye Corp., 40 Rector St., New York 6.

The Coleman photo-electric colorimeter Model 8 is described and illustrated in Bul. B-214 available from E. Machlett & Son, 220 E. 23 St., New York 10, upon request. The instrument features removable scales, six selected filters which cover the visible spectrum and a photocell operating at extremely low levels to give better linearity and freedom from drift.

A portable pipe threading device which can be attached to any standard set of dies and be driven by any ½-hp., heavy duty electric drill, Porta-Drive is the subject of a four-page bulletin distributed by Muncie Gear Works, Inc., Muncie, Ind. The tool is actually a 20 to 1 gear reduction unit and can be applied to thread pipe—in place or in any position—up to six in. in size.

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"Unitized Laboratory Furniture" is a brochure showing standard laboratory furniture units available from stock at Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, and Eimer and Amend, Greenwich & Morton St., New York 14. In addition, a complete catalog giving specifications and prices of all units is available on request.

Sectional units, tables, cabinets and other laboratory items produced by Metalab Equipment Corp., 1529 Dean St., Brooklyn 13, N. Y., are described in a new catalog. A section offering suggestions on practical laboratory planning and the solution of layout problems is included.

"The Magnesium Anode," the first issue of which has appeared, is a publication to be distributed at regular intervals by Dowell Incorporated, Tulsa 3, Okla. The publication will be concerned with the applications of magnesium for the cathodic protection of metal structures.

The prompt availability of Taylor Spiral-Weld Pipe from plants in Carnegie, Pa., and Fontana, Calif., is announced in a bulletin distributed by Taylor Forge & Pipe Works, Box 485, Chicago 90, Ill. Dimensions, test pressures and weight of lengths are also included in the bulletin, No. 493, which may be had on request.

A "Composite Water Well Supply Catalog," containing 110 pages of catalog information on all the equipment necessary to drill and produce a well, is being distributed by Water Well Dept., National Supply Co., Box 416, Pittsburgh 30, Pa.

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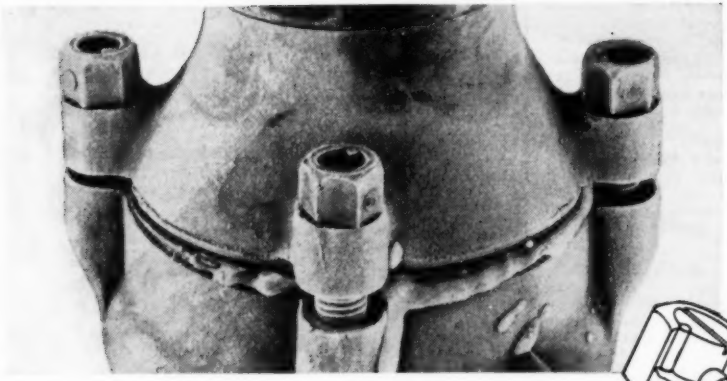

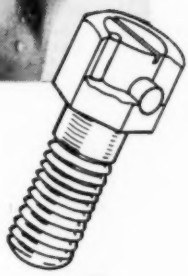

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Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
Northrop & Co., Inc.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Hellige, Inc.
Klett Mfg. Co.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Goosenecks (with or without Corporation Stops):
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Greensand; *see* Zeolite

Hydrants:
James B. Clow & Sons
M. Greenberg's Sons
James Jones Co.
Kennedy Valve Mfg. Co.
John C. Kupferle Foundry Co.
Ludlow Valve Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Michael Hayman & Co., Inc.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
Carson-Cadillac Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Dresser Mfg. Div.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Lime Slakers and Feeders:
Dorr Co.
Infilco, Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)

Magnesium Anodes (Corrosion Control):
Dowell Incorporated

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Art Concrete Works
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.
Buffalo Meter Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Standard Pipeprotection, Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Everson Mfg. Corp.
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Fairbanks, Morse & Co.
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

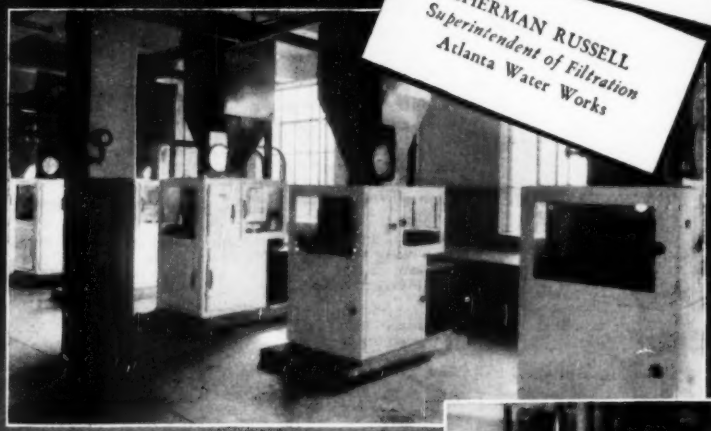
ATLANTA, GA.

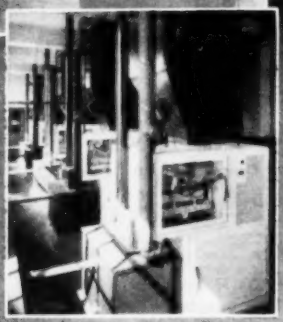
Atlanta Water Works

(Completed in 1946)

PAUL WEIR, *General Manager*
Atlanta Water Works

SHERMAN RUSSELL
Superintendent of Filtration
Atlanta Water Works





Under the direction of Paul Weir, Genl. Mgr., and Sherman Russell, Supt. of Filtration, an up-to-date taste and odor control program initiated ten years ago at Atlanta Water Works has been brought to successful completion. This water works now supplies almost 72 MGD of pure, palatable water to the metropolitan Atlanta area. Clay, carbon, alum, and lime are fed by Omega Gravimetric Feeders to water supplying three filtering units: one 18 MGD pressure filter plant and two gravity type rapid-sand filter plants of 21 and 33 MGD capacities, respectively. For Bulletins describing Omega equipment, address Omega Machine Company, (Division of Builders Iron Foundry), Providence 1, R. I.

Omega equipment furnished Atlanta Water Works:

8 Belt-type Gravimetric Feeders with Rate of Feed Recorders, Mixing Chambers, Storage Hoppers, and Dust Collectors.

1 six-unit Laboratory Stirrer.

THE LAST WORD IN FEEDERS

OMEGA

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages:
(See Gages)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Permutit Co.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco, Inc.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr Co.
Everson Mfg. Corp.
Hungerford & Terry, Inc.
Infilco, Inc.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

HYDRO-TITE

JUST POUR

THAT'S ALL

Hydro-tite, the self-caulking, self-sealing, pipe-jointing compound, solidifies and hardens immediately without shrinkage. No caulking is necessary. Any slight seepage that may appear at first soon stops.

For over thirty years Hydro-tite has proved its ability to stand up under all conditions of strain, vibration and pressure. Send for data book and sample.

ALWAYS USE FIBREX

The sanitary, bacteria-free packing that costs about 30% less than braided jute. Send for sample.

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: 50 Church St., New York, N. Y.

Works: West Medford Station, Boston, Mass.

The "Great Gildersleeve"*

*STARRING HAROLD PEARY—ON THE AIR FOR KRAFT FOODS COMPANY OVER N.B.C.

. . . THROWS CURVES AT WATER CONSUMERS

Chester Conklin, former meter reader (now promoted to maintenance) watches wistfully as new Meter Readerettes salute The Great Gildersleeve before starting out to read 'em.

Hydrants present a tough hurdle. "This doesn't look like the meter Mr. Gildersleeve showed us . . . but maybe it's the large economy size."

"I wonder what they mean by a curb meter? It just says here: 'Unscrew the disaflous, then the samastrope will be in plain view'." (The gal can't even read the manual.)

PITTSBURGH-EMPIRE METERS

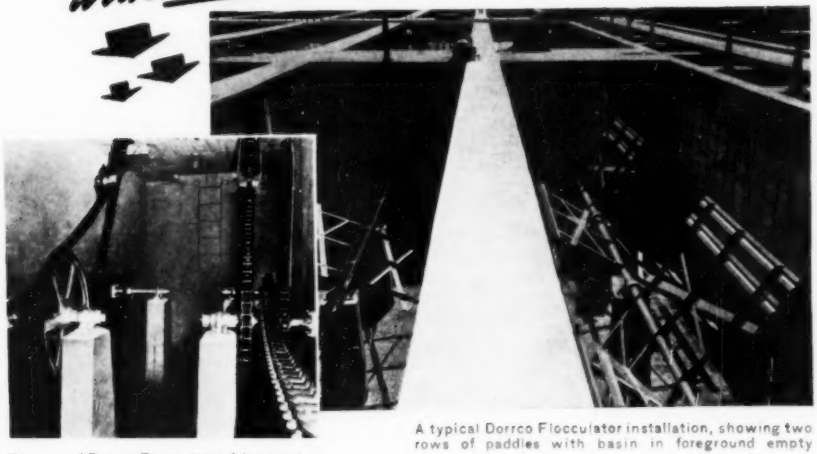
PITTSBURGH EQUITABLE METER DIVISION
ROCKWELL MANUFACTURING COMPANY
PITTSBURGH 8 PA.

Atlanta Boston Chicago Houston Kansas City Los Angeles
New York Pittsburgh San Francisco Seattle Tulsa

But seriously speaking, you can always read Pittsburgh-Empire meters and profit from their accuracy.

Next month Gildy finds out the girls can't read meters either—

10 years continuous operation with DORRCO FLOCCULATORS *without trouble!*



A typical Dorrco Flocculator installation, showing two rows of paddles with basin in foreground empty

Closeup of Dorrco Flocculator drive mechanism showing completely enclosed dry well

That's the actual case history of a Dorrco Flocculator installation at a large Eastern water treatment plant. The water works superintendent reports absolutely no trouble with bearings, paddles, or drive mechanism since this unit was first installed in 1939 at a design capacity of 10 M.G.D. This is typical of the operating dependability you get with Dorrco Flocculators. The dry well feature means that the entire drive mechanism is never exposed to water and is readily accessible at all times.

If you have existing plain basins, chances are they can be converted easily—and at a substantial saving in cost. New plant or modernization, Dorrco Floculators will improve your entire pre-treatment operation. A close check on one installation after only three months of operations showed:

- **Filter runs lengthened 40%.**
- **Wash water demands reduced 30%.**
- **Alum costs cut 30%.**

Why not write for further information concerning the savings and increased efficiency that Dorrco Flocculators can achieve in your plant?

ADDITIONAL FEATURE FOR MAINTENANCE ECONOMY

An important optional design feature of the Dorrco Flocculator is the Automatic Lubricator for submerged bearings. Actuated by the shaft rotation, it contains over a year's supply of grease and insures trouble-free bearing operation at all times.

DORRCO

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DENVER • LOS ANGELES
RESEARCH AND TESTING LABORATORIES
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Dorr Technical Services and Equipment Are Also Available Through Associated Companies and Representatives in the Principal Cities of the World. Names and Addresses on Request.

DORR

RESEARCH ENGINEERING EQUIPMENT

LEADITE

Trade Mark Registered U.S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking